APRIL 1960

Power Engineering

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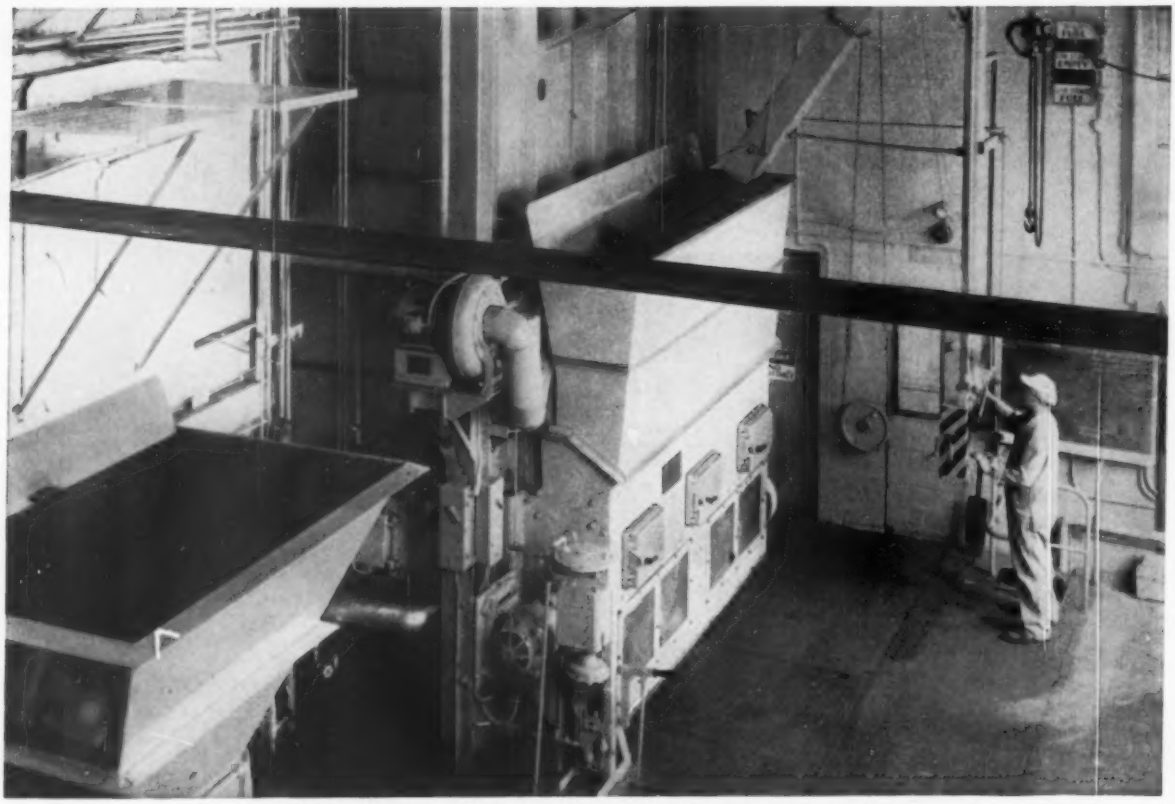
Circulation of This Issue 43,101

at S. C. Johnson & Son, Inc.



On the line in October 1954, this 40,000-lb B&W boiler, fired by AE Vibra-Grate Stoker, has never had an unscheduled shutdown. Cost of repairs to previous stokers ran close to $1000 per year.

Five-year repair bill for Vibra-Grate Stoker...only $188!

(vs previous stoker costs of $1000 a year)

The AE Vibra-Grate Stoker installed at S. C. Johnson & Son, Inc. (makers of Johnson's Wax Products), Racine, Wisconsin, continues to prove every performance promise ever made for Vibra-Grate Stokers.

Read these highlights from the company's *five-year* maintenance report, just released:

No unscheduled shutdowns. Savings of 919 tons of coal per year. No fly ash collector needed. No trouble with clinkering or coking coals. Peak efficiency at plant loads from 4000 lb per hour to 45,000 per hour. Load swings of 15,000 to 20,000 lb with only 3 to 4 lb variation in pressure.

Finally, total repair costs only $188, while burning 34,962 tons of coal . . . just slightly over ½ cent per ton of coal!

The AE Vibra-Grate Stoker is the only stoker which combines the long life and low maintenance of water-cooled grates with the high efficiency of vibrating grate feed and controlled zone undergrate air. No other stoker cuts maintenance costs so drastically, gives such highs in efficiency. Get the complete design and operating story. Write today to Dept. S-101 for our Vibra-Grate Stoker Catalog S-546-A.

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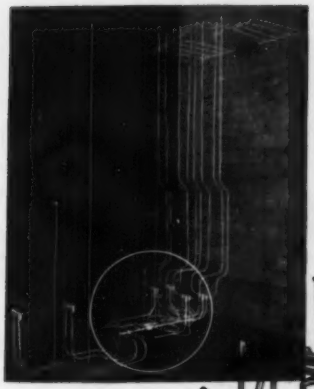

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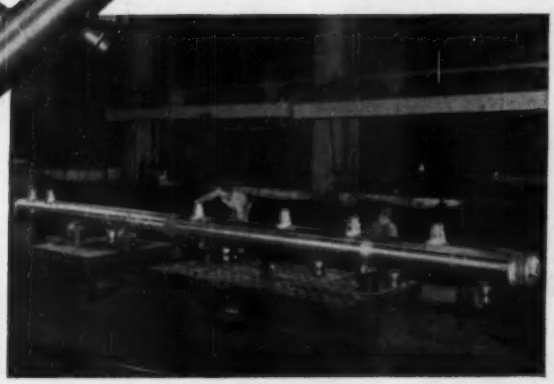
for High-Temperature, High-Pressure Service by

Pittsburgh Piping

16,500 lb. Stainless Steel Main Steam Header

PART OF A COMPLETE PIPING SYSTEM



Stress analysis of a model of power piping is an established procedure at Pittsburgh Piping. It is used to predict accurately the physical reactions of high-temperature, high-pressure piping in service.

The photograph at top left shows a model of main steam piping which is part of a complete system shop fabricated and field erected by Pittsburgh Piping. The enlarged section of the model indicates the relative size and location of the main steam header. This header, shown in the main photo, is fabricated of Stainless Steel Type 316. It weighs 16,500 lbs. and its wall thickness is 3".

Model testing and shop fabrication are two phases of Pittsburgh Piping service which covers every aspect of a piping job—from blueprint through erection. We are specialists—thoroughly experienced in the theoretical and practical aspects, as well as in the code and insurance requirements of high-temperature, high-pressure piping.

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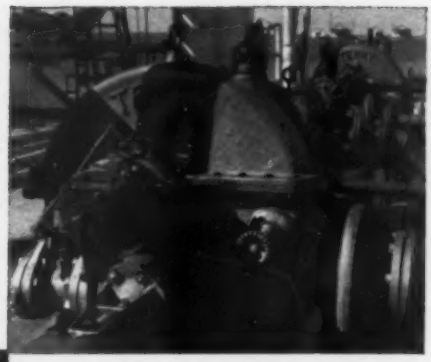
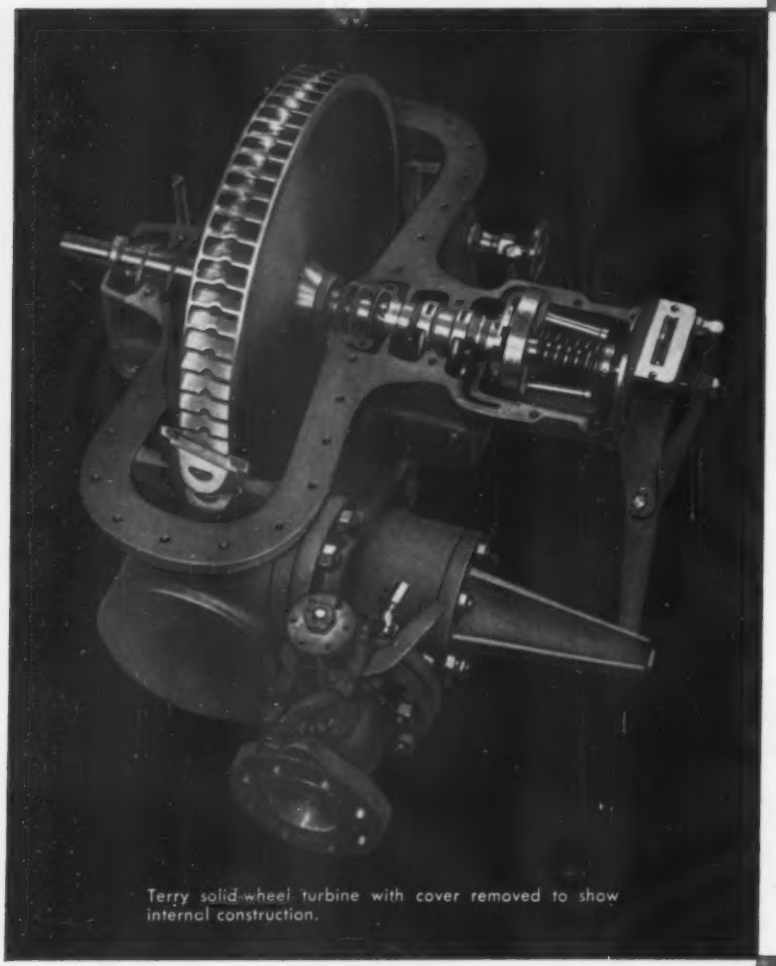
TERRY SOLID-WHEEL TURBINE

spells service continuity for mechanical drives





Terry solid-wheel turbine with cover removed to show internal construction.

For mechanical-drive applications, such as these, you will never find the equal of Terry solid-wheel turbines for built-in dependability. They are *designed* for trouble-free operation under the toughest service requirements.

The wheel, for example, is a single forging of special composition steel. Unlike a built-up wheel, there are no separate parts to loosen or work out. The blades can't foul since they are double-rim protected...with one-inch clearances at either side.

Any blade wear, which might occur after years of service, is of little consequence. As the power-producing action of the steam takes place on the curved surfaces at the backs of the buckets, wear does not materially affect horsepower or efficiency.

Specify Terry solid-wheel turbines for your next mechanical drives. They are available in capacities from 5 to 2,000 hp., speeds up to 10,000 rpm. Vertical turbines are built in sizes from 5 to 300 hp.

For full information about these reliable turbines, send for bulletin S-116.

THE TERRY STEAM TURBINE CO.
TERRY SQUARE, HARTFORD 1, CONN.

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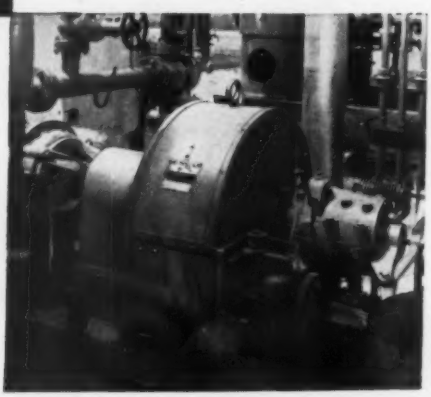

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PUBLISHED SINCE 1896 FOR POWER ENGINEERS IN PRIVATE AND PUBLIC UTILITIES AND INDUSTRIAL ARTS

ENGINEERS' PREVIEW

● 400,000-KVA transformer — the highest capacity unit ever to be built by General Electric — has been ordered by the Public Service Electric and Gas Co of Newark, N. J. The 230-kv step-up unit will be installed at the company's Sewaren generating station in July, 1961. The new power transformer is believed to be the highest-rated two winding unit ever to be built or on order in this country. The previous G-E record was two 375,000-kva units. Ten years ago, the largest unit shipped by the company was rated 145,000 kva.

● FOR THE SECOND consecutive year, enrollment in America's accredited engineering colleges has dropped, reports the American Society for Engineering Education. Last fall 240,063 students registered in engineering; year before there were 249,950, and in the fall of 1957 the total was 257,777.

Under the influence of high enrollments in the mid-1950's, the number of engineering graduates continues to rise; in the year ending in June, 1959, 41,132 degrees were given in various fields of engineering. But a study of recent enrollments would indicate that there will be fewer engineering graduates within the next one or two years.

The Society's figures, compiled by the U.S. Office of Education, come from 154 engineering schools in the United States, and cover all engineering colleges with one or more engineering curricula accredited by the Engineers' Council for Professional Development.

B. R. Teare, Jr., president of ASEE states, "This continued decrease in enrollment, and particularly the decrease in freshmen, is a matter of great concern to all of us. The studies of the Engineering Manpower Commission indicate not only that the demand for engineers is increasing, but also that it is expected to accelerate."

Engineering enrollments for advanced degrees continued to show increases in the fall of 1959, but the rate of growth is decreasing.

● AEC has ruled that regional disposal of low-level packaged radioactive waste materials shall be established, as needed, on State or Federal government-owned land. This will assure adequate protection of the public health and safety throughout the period of any potential hazard.

The publicly-owned disposal installations would be operated by private contractors or licensees under strict government controls or by the Federal or State government and would be available to all users of radioactive materials.

Land requirements for disposal sites are not expected to be large. Over the last 15 years, low-level solid or packaged wastes at Oak Ridge have been safely handled in approximately 60 acres. On the basis of this experience it is estimated that all such wastes generated between now and 1980 in the 16 states in the northeast area, for example, could be safely disposed of in a 200- to 300-acre site.

It is expected that the first regional site will be needed in the northeastern part of the country where there is a relatively heavy and growing concentration of industrial, medical, university and other users of radioisotopes. The needs of other regions will be met later on as they develop.

● THIRD Annual Power Instrumentation Symposium will be held in San Francisco, May 9-11, under the auspices of the Power Industry Division of the Instrument Society of America. Theme of the sessions, all of which will be held in San Francisco State College, is Progress in Control Systems.

The Instrument Society of America also will hold its Summer Instrument-Automation Conference and Exhibit in San Francisco May 9-12, but separately from the Power Instrumentation Symposium.

Fluid Controls Institute will hold its spring meeting at The Greenbrier, White Sulphur Springs, W. Va., May 11-14.

Eleventh annual conference of the Rural Electric Generating Cooperatives will be held May 23-26 at the Stoddard Hotel, La Crosse, Wis.

Third annual ASME-AIEE Joint Automatic Techniques Conference will be held at the Sheraton-Cleveland Hotel, Cleveland, April 18–19. Institute of Radio Engineers is also a sponsor.

1960 National Telemetering Conference is scheduled for May 23–25 at the Hotel Miramar, Santa Monica, Calif. Conference is sponsored by AIEE, ISA, Institute of the Aeronautical Sciences, and the American Rocket Society.

Air Pollution Control Association meets May 22–26 at the Netherland-Hilton Hotel in Cincinnati.

32nd annual Oil and Gas Power Conference, sponsored by ASME, will be held in Kansas City, Mo., May 22-26. Engine power economics will be the main subject.

National Industrial Service Assn, international trade organization of electrical apparatus service companies, will hold its 27th annual meeting in Miami Beach, May 8 to 11.

TITUS G. LeCLAIR has become manager of nuclear power applications for General Dynamics Corporation's General Atomic Division. Le Clair comes to General Atomic from Chicago, where he has been manager of research and development for Commonwealth Edison Co. He has been an official of the Nuclear Power Group, Inc, which co-sponsored Commonwealth Edison's recently completed Dresden nuclear power plant. He also has served in advisory capacities to the Atomic Energy Commission and Joint Congressional Committee on Atomic Energy.

Albert Haertlein, Associate Dean of Engineering and Applied Physics at Harvard, has been given an Award of Merit by the Engineering Societies of New England "in recognition of his long and outstanding service to the engineering profession."

Herbert P. Sedwick has received the 1960 Washington Award of the Western Society of Engineers, "for leadership and achievement in electric and gas utilities, for true service in educational and humanitarian fields and for developing young engineers." Sedwick retired in 1958 as president of the Public Service Company Division of Commonwealth Edison Co after nearly 45 years in the Chicago area utility industry.

George Washington Honor Medal Award has been presented to Elmer L. Lindseth, president of the Cleveland Electric Illuminating Co, by the Freedoms Foundation at Valley Forge, for his public address, The Vanishing American. The address was presented January 29, 1959, before the Rotary Club of Cleveland, and was reprinted in the *Congressional Record*. It dealt specifically with the alarming growth of improper government participation in business.

BCI is now the Bituminous Coal Institute Division of the National Coal Association's Marketing Department. As the market promotion agency of NCA, it will continue to work for coal selection by plant management, architects and consulting engineers.

W. W. Bayfield, formerly executive vice-president of American Coal Sales Association, now merged with NCA, is vice-president in charge of the newly created Marketing Department. Carroll F. Hardy, formerly managing director of BCI, is director of the BCI Division. Harry C. Ballman, formerly manager of BCI field engineering services, is director of the Air Pollution Control Division. Paul L. Brown, formerly in charge of ACSA's salesmen and management training program, is director of the Manpower Development Division.

The Marketing Department will also supervise the management of Automatic Solid Fuels Equipment, Inc, the name of which has been changed to Bituminous Coal Equipment, Inc. Frank Kirkpatrick will continue as managing director.

POWER SUPPLY more potent than the power supply of any other major atom smasher in the United States has been ordered by the Argonne National Laboratory for its Zero Gradient Proton Synchrotron, a huge particle accelerator now under construction at the Laboratory's main site near Lemont, Ill.

The power supply will include a 68-ton steel flywheel, 13 ft in diameter. Spinning at approximately 900 rpm, this flywheel will store enough kinetic energy to power an express train. The flywheel will generate electric power in surges of 117,000,000 watts for the 4000-ton circular magnet of the 12.5 billion electron-volt Argonne atom smasher. Pulses of 117,000,000 watts of electricity will be delivered to the magnet every four seconds. This is enough power to light 1,170,000 100-w bulbs.

The power supply will produce a maximum current of 11,000 amperes and a maximum voltage of 12,500 volts. It will feed electricity into the magnet in pulses of one second duration, 15 times a minute. Allis-Chalmers will build the power supply unit.

Purpose of the Zero Gradient Proton Synchrotron, to be completed in 1962 at a cost of $29,000,000, will be to fire high energy proton "bullets" at nuclear targets. This will enable scientists to take apart the atom and explore the fundamental nature of energy and matter.

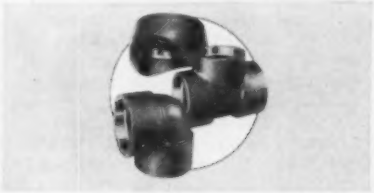
SEVEN historic theaters, owned by J. J. Shubert and representing nearly one quarter of New York's entire Broadway legitimate theater district, will be mechanically air conditioned for the first time by summer. An ingeniously designed hook-up by Worthington Corp will link all seven theaters to a master air conditioning system, which will be located out of sight under famed Shubert Alley. The new system replaces ice-chilling systems, which have required up to $6000 worth of ice a week, to cool the seven theaters during hot weather. The seven Shubert theaters included in the project are: Shubert, Broadhurst, Majestic, Booth, Plymouth, Royale, Golden.

FUTURE ENGINEERS OF AMERICA, a non-profit organization set up by a Chicago group of engineers and educators, stimulates interest in science among high school students by staging "brain" contests. Last year 550 students from 25 states participated in the finals of FEA's applied math tournament held at the Technological Institute of Northwestern University in Evanston, Ill. A similar contest is now underway, with a grand tournament scheduled to be held in Chicago on April 16.

A Bonney forged cupro nickel sockolet fitting being fusion welded to a cupro nickel pipe.

NEW FORGED CUPRO NICKEL FITTINGS SIMPLIFY INSTALLATION OF PIPING SYSTEMS

A considerable saving in the installation of cupro nickel piping systems can be effected by the use of forged cupro nickel welding fittings like those shown on this page. They make it possible to install full lengths of pipe or tubing and cut in branches afterward without the use of complicated fittings and sizing techniques.

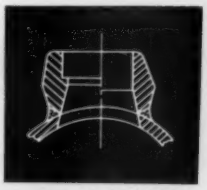


Bonney Forge and Tool Works, Allentown, Pa., drop forges socket welding outlets (sockolets), socket tees, and socket elbows from Anaconda Cupro Nickel, 10%-755 and Cupro Nickel, 30%-702 rod. They are widely used in salt water lines for both Naval and commercial applications.

The trend to higher water velocities in salt water lines—plus the growing economic importance of uninterrupted continuity of service—on shipboard and in tidewater power plants and oil refineries is leading to an increasing use of cupro nickel in piping.

The alloy coming rapidly into prominence is Cupro Nickel, 10%-755, developed by Anaconda for this kind of service. It has much of the corrosion resistance of Cupro Nickel, 30%-702, but costs considerably less. It is resistant to corrosion by both clean and polluted sea water, even at relatively high velocity of flow, and is resistant to corrosion by sea water containing air bubbles.

TECHNICAL ASSISTANCE. The Metallurgical Department of The American Brass Company is regularly working with manufacturers and users of heat transfer equipment and systems, helping to select the alloys best suited to the service. For technical help or information on alloys and tubes, write The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 6065



Bonney cupro nickel fittings for fusion welding to cupro nickel pipe are available for socket weld or silver braze of outlet (left, in drawing) or for butt weld of outlet (right), and for threading of outlet (not shown). Size range: outlet, ¼"-6" for run pipe sizes, 1"-24".

ANACONDA®

COPPER AND COPPER ALLOY MILL PRODUCTS

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WHAT THEY TELL US

▶ **CAN ANY READER** help W. E. Hoffman, who writes this department:

> Recently it came to my attention that a firm in West Germany is manufacturing a balloon device of half-inch thick Neoprene which can be installed in coal or sand hoppers to break jam-ups in the discharge spout. I understand that the rubber is backed by a steel base plate through which compressed air is forced to inflate the rubber and dislodge the blocking material.
>
> We are handling culm grade anthracite through cone bottom bunkers, with frequent jam-ups in the spouts to the boilers.
>
> Could you or any of your readers help me find the manufacturer of these balloons? Has anyone had any experience with these or similar devices in such an application?

▶ **REPLYING** to one of our reader surveys which seek improved ways of presenting information in POWER ENGINEERING, A. B. Liggat of the engineering staff of the Canadian Pacific Hotels, writes:

> At the moment I cannot recommend any changes in your publication, as I find it quite satisfactory in its present form. I find your data order cards very helpful, and I endeavor to find time to go over each issue throroughly as soon as I receive it. My office contains all the back issues, which are available to our shift engineers at all times, for reference.
>
> Again thank you for the job you are doing so well in bringing information to out-of-the-way places, of new and improved products as they appear on the market.

▶ **WESTINGHOUSE** engineers have developed a new insulation that can simply be sprayed or painted on electrical equipment subject to high-voltage discharges, and which reportedly gives standard insulating materials as much as 300 times more resistance to breakdown by arcing or "tracking." Explains Dr. C. E. Arntzen:

> Tracking occurs when electricity skips across the surface of electrical insulation, causing a short circuit. This is most acute when moisture or dust contaminate the surface. These contaminants are the origin of tiny individual electric arcs which cause hot spots on the surface of the insulation. Under this, ordinary insulating materials tend to "unlink." That is, their large complex molecules break down into simpler ones, finally depositing carbon which can conduct electricity and form a continuous path for an electrical discharge. The electricity then tracks across the surface, chars the insulation and shorts out the apparatus.

▶ **READER** J. William Glenn, Jr, writes from Massachusetts:

> My company is concerned with nuclear reactors, and it tickles me that in POWER ENGINEERING I first read of "masers," and your section ATOMICS arrives two or three days earlier than the leading publication in our field, and sometimes scoops that magazine. ATOMICS is required reading in our R & D department.

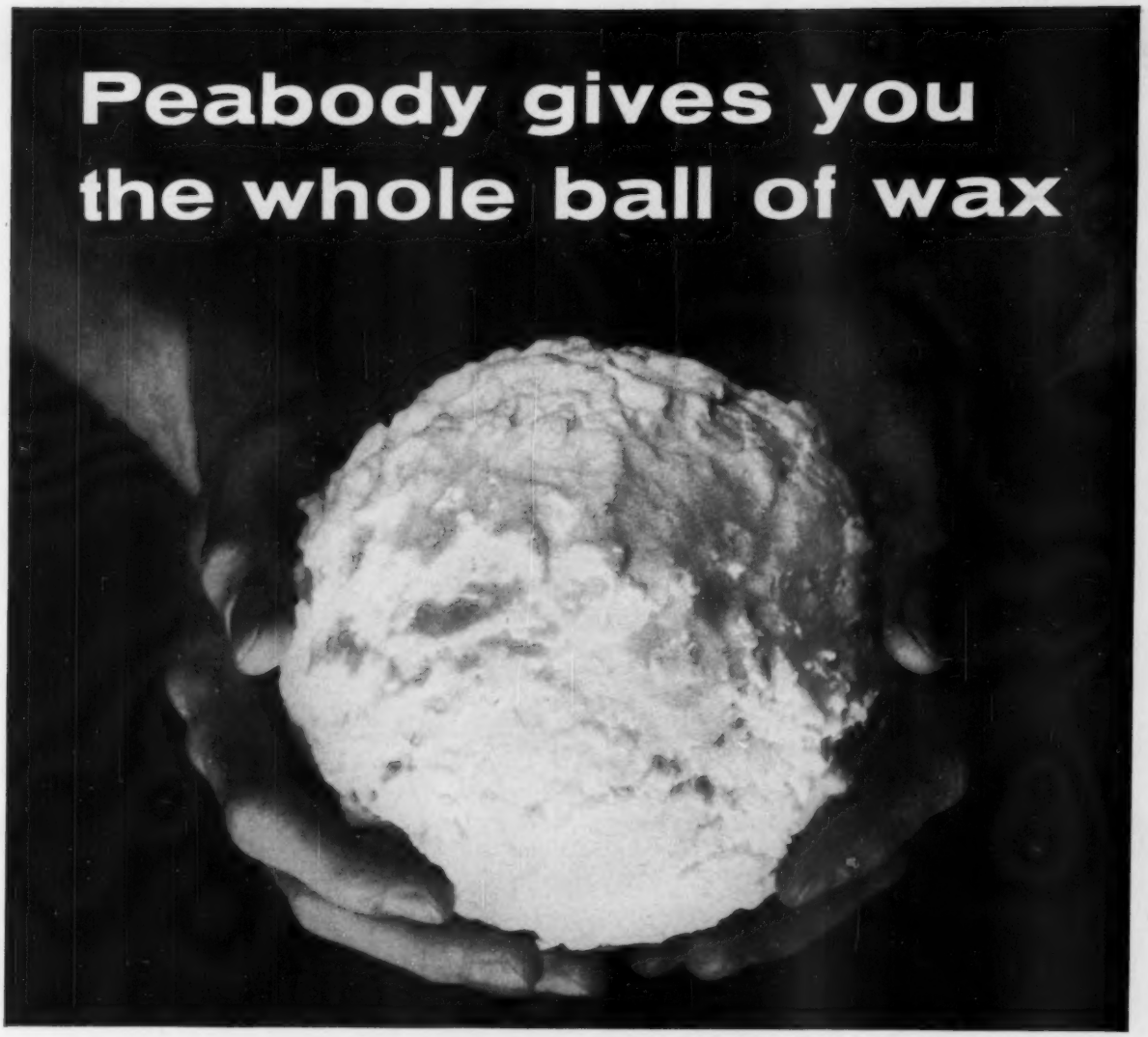
▶ **MEMPHIS** turbine repair experience, detailed in POWER ENGINEERING, Sept, 1959, page 79, was commented on in this department in January by reader W. Cronin of Dublin, Ireland. Now we have the following comment on Cronin's comment — this one from D. W. R. Morgan, Jr, of Westinghouse's Large & Medium Turbine Dept:

> We were particularly interested in Mr. Cronin's statement that such a failure could not have occurred on a European-built steam turbine because of the superior design and construction of their blades. He pointed out that European turbine manufacturers would use blades having integral, rather than riveted-on, shrouds with these blades combined into groups by welding adjacent integral shrouds together.
>
> As you know, the use of shrouds and the controlled methods and special tools used in attaching these shrouds to the blades have received a tremendous amount of attention from the standpoints of metallurgical research, supplemented by mechanical and thermodynamic design and by testing in the laboratory and on actual turbines. Our blade design permits ample tenon for high quality riveting of the shrouds to the blades.
>
> Although Mr. Cronin states that most European manufacturers use the integral shrouds, we know that several use a construction quite similar to ours.
>
> He also questions whether the material of the shroud is austenitic. This material is 12 per cent chrome steel, which is the same as that of the blade, both of these materials being ferritic.
>
> Mr. Cronin is correct in stating that the lashing wires should not be welded to the surface of the blade because of the harmful effect on the blade material. To avoid this, we have for several years been forging lashing wire stubs integrally with the blades. Welding between these stubs to form groups of blades is thus done at some distance from the blade surface and therefore has no harmful effect on the blade proper.
>
> We wish to thank Mr. Cronin for his interest in this matter and can assure him that we are continually striving for perfection in the design and manufacture not only of blades but of all our turbine elements.

▶ **D. I. CALLEJA,** a power plant engineer in Key West, Fla, keeps in touch with this department with comments on problems he encounters along the way. Here's the latest:

> I have noticed recently that all the switchgears are installing either megavars or kilovars meters instead of the power factor type.
>
> This I find very unwise. First, to know the power factor on these meters one has to refer to some kind of table or graph that has been prepared to show the conversion. Second, in plants that have a few engines on the line, it's very hard to know the power factor on each engine, and at times some of these plants don't even have a way of finding out. Third, the power factor meters are better for operation, as one can set all the engines to have the same power factor, getting better efficiency by having all engines take the same share of the load; and when taking one engine off the board one can see that the power factor does not get below 80 per cent, which will void a radical change on other engines.
>
> I am presently operating at a plant where there is no way of telling the power factor on about four engines, as the board is only furnished with RKVA meters. This operation always keeps the wheels of the meters on all the machines at the same speed, or as a rule uses the figure four to multiply the a-c amp. Example: if the engine has 400 kw, one must have at least 100 a-c amp (4 x 100 = 400 kw). The bus voltage is 2400 v. I know of no way to figure the power factor with this set-up. Crazy, man, crazy.
>
> I can't see for the life of me why the companies that make electrical equipment for power plants allow these meters to be installed, as with power factor meters operation would be better.

Peabody gives you the whole ball of wax



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Every step of the way, Peabody customers get individual attention. Peabody's trained combustion engineers will help you select the most efficient coal-burning equipment, or convert your present equipment to coal. They will help determine the *right* coal for your specific needs, and advise you in its most economical utilization. Your coal is mined by the most modern methods . . . then tailor-made in Peabody's automated Processing Plants under rigid laboratory control—accurately sized, washed and heat-dried. Company-owned railroads, high-capacity loading docks on the inland waterways and major trunkline railways bring you on-schedule deliveries.

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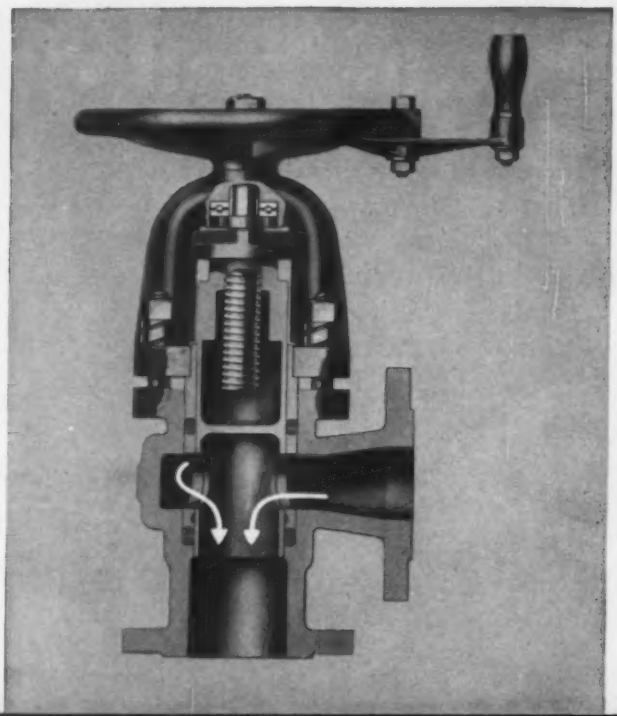
YARWAY SEATLESS

Features balanced nitralloy hollow plunger that seals line drop-tight, yet permits free, unobstructed flow in blow-down. Other features —laminated packing, alemite lubrication, ball thrust bearings. USED SUCCESSFULLY IN OVER 15,000 BOILER PLANTS.



FOR LOW and MEDIUM PRESSURES

YARWAY HARD-SEAT

Features tough, stellite-faced and ground disc and seat ring, mated to provide smooth long-wearing surfaces. Stream-line flow. Alemite lubrication. MORE THAN 4 OUT OF 5 HIGH PRESSURE BOILER PLANTS USE YARWAY BLOW-OFF VALVES.

FOR HIGHER PRESSURES

USED IN OVER 15,000 BOILER PLANTS

serve every boiler blow-down need

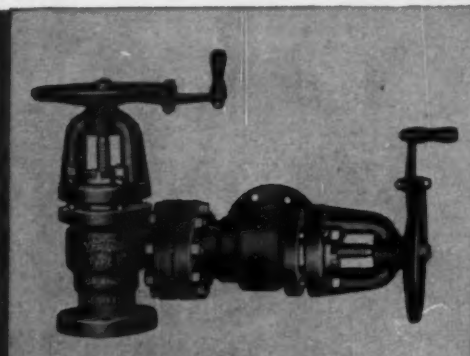
■ Whatever your *pressure* requirement, whatever your *piping* requirement—there's a Yarway Blow-Off Valve to exactly meet your needs.

Popular Yarway *seatless* design keeps blow-down lines drop-tight in low and medium pressure ranges. Sturdy Yarway *stellite seat and disc* design protects higher pressures.

All Yarway Blow-Off Valves are strong, rugged valves, built to withstand the punishment of regular or emergency blowing-down under full boiler pressure, and are available in metals that stand up under acid washing of boilers.

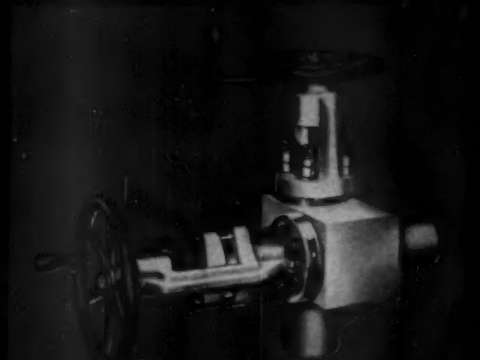
Write for new Yarway Blow-Off Valve Bulletins—B-426 (pressures to 400 psi) or B-434 (pressures to 2500 psi).

● Yarway Type B Seatless Blow-Off Valve, iron body for boiler pressures to 200 psi, steel bodies, for pressures to 400 psi. Angle valve shown, straightway available. Flanged connections. See Bulletin B-426.



● Yarway Type B Seatless Tandem Blow-Off Valve combining two angle valves. Other combinations available. Iron bodies for boiler pressures to 200 psi, steel bodies for pressures to 400 psi. See Bulletin B-426.

● Yarway Type C Seatless Tandem Blow-Off Valve combining angle and straightway valves. Other combinations available. Flanged or welding connections available. For boiler pressures to 600 psi. NOTE: When used in tandem with a Yarway Hard-Seat Valve, Type C Seatless may be used to 1500 psi. See Bulletin B-434.



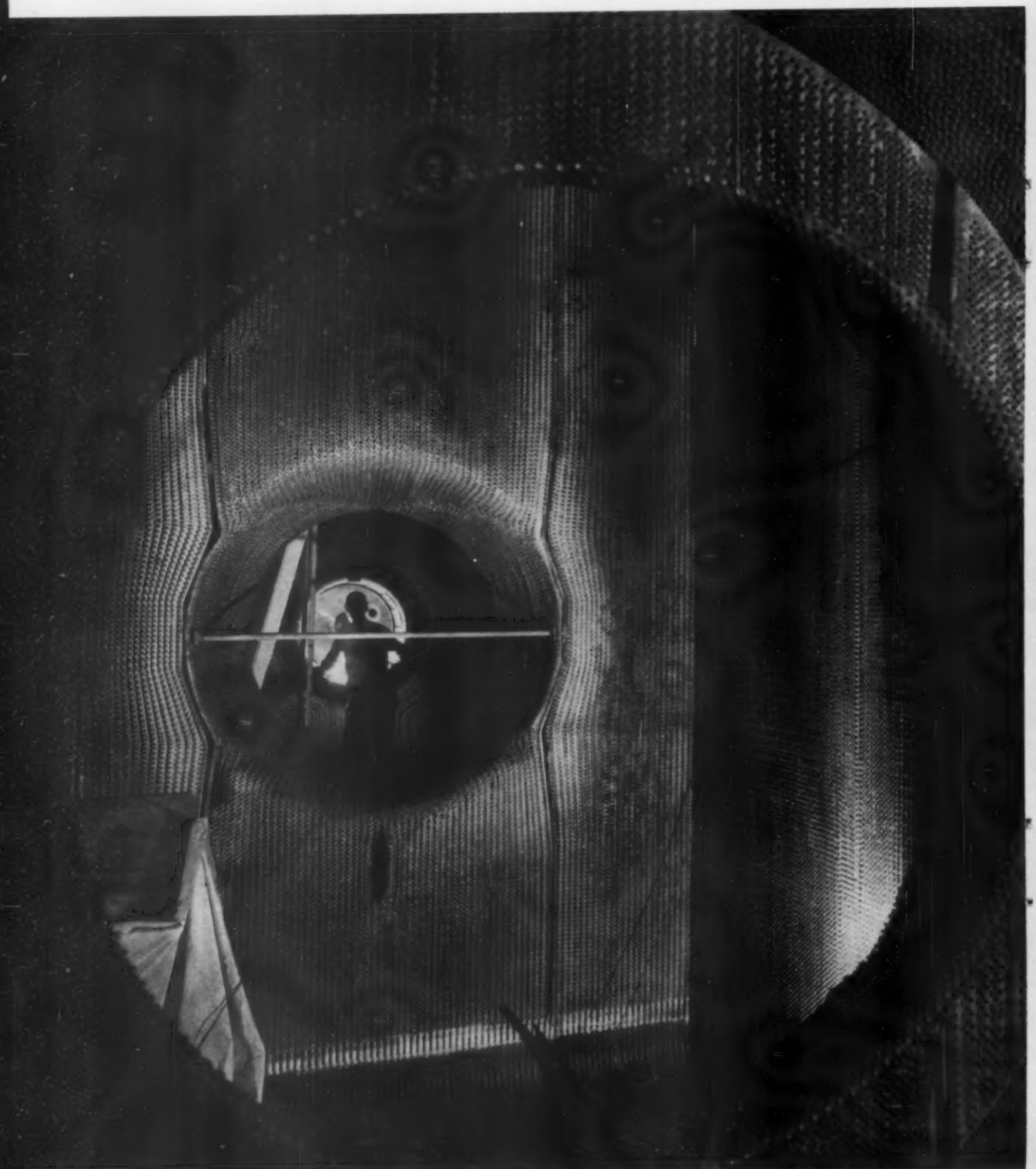
LET YARWAY HELP SOLVE YOUR BOILER BLOW-DOWN PROBLEMS!

YARNALL-WARING COMPANY
100 Mermaid Avenue, Philadelphia 18, Pa.
BRANCH OFFICES IN PRINCIPAL CITIES

YARWAY

blow-off valves

"Cheap and dirty" coal....



..a premium performer in the

B&W Cyclone Furnace

Low-cost, unwashed, high-ash coals actually aid efficient combustion in the B&W Cyclone Furnace

Low grade coals are effectively fired in the B&W Cyclone Furnace with a continuous high velocity blast of secondary air, causing a cyclonic turbulence. Ash in the coal is melted to form a viscous fluid bed around the cylindrical furnace walls. This slag bed traps incoming coal on its surface, letting the high velocity secondary air scrub the coal, burning out maximum Btu's. More than 80% of the ash is trapped in this liquid slag and tapped into slag tanks before entering the secondary furnace.

So—the high slagging characteristics of low-cost, unwashed, low-fusion-temperature coals make them an *especially attractive* fuel!

In addition, B&W Cyclone Furnaces offer all of the following advantages:

- **Simplification of coal burning equipment**
- **Less atmospheric pollution**
- **Elimination of fly ash handling and disposal problem by reinjection system as a part of the unit**
- **Less space, smaller building**
- **Less maintenance and cleaning**
- **Safer operation, simpler remote control**
- **Increased availability**

The unit under construction on the left is one of the more than 325 B&W Cyclone Furnaces to be erected to meet the increasing needs for maximum efficiency of energy conversion in the power industry. We would welcome an opportunity to put the advantages of a B&W Cyclone Furnace in *your* language. For further details, please contact your local B&W representative . . . or write for B&W Bulletin G-65. Address: The Babcock & Wilcox Company, Boiler Division, Barberton, Ohio.

G-965

B&W

THE BABCOCK & WILCOX COMPANY

BOILER DIVISION

For more data circle 507 on Post Card

NOW! Fuses that...

Safely interrupt fault currents up to 200,000 amperes...

Limit fault current to very low values

Hold 500% load for minimum of ten seconds

Buss Low Peak fuses can completely revolutionize the protection of the entire electrical system.

Protect Mains, Feeders, Branch Circuits, Motors, Controllers, Switches—no matter whether the fault current is 1,000 amperes, 25,000, 100,000—or as high as 200,000 amperes.

Reduce stresses and prevent damage to Panel-boards, Switches, Motor Controllers—other circuit components—because let-thru fault currents are limited to exceptionally low values.

Prevent work stoppages, lights out, waste of time and money—because long time-lag keeps them from opening needlessly on motor starting currents or other harmless overloads.

Permit increasing interrupting capacity and current limitation on present system at minimum cost.

Before designing a new installation— or modernizing old installations—

GET ALL THE FACTS

Knowledge without action is of little value—but ACTION NOW may save you money—increase operating efficiency and reduce electrical hazards to a minimum.

BUSS LOW-PEAK fuses fit standard Switches and Panel-boards and are available in N.E.C. sizes from 15 to 600 amperes in both 250 and 600 volt ranges.

Write for BUSS LOW-PEAK Bulletin Now . . . or use coupon.

Bussmann Mfg. Division
McGraw-Edison Co.
St. Louis 7, Mo.

BUSS
Low-Peak
FUSES

Bussmann Mfg. Division, McGraw-Edison Co.
University at Jefferson, St. Louis 7, Mo.
Please send BUSS Low-Peak Fuse Bulletin LPS.

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Title.....

Company.....

Address.....City.....State.....

PWE-460

For more data circle 508 on Post Card

The Story of Edward Research

and the Leak-proof Valve

In the early 1940's, the advance of steam power plant pressures and temperatures demanded a leak-proof, small sized valve—one with permanent tightness at the seat joint and one which would solve the failures of mechanical gasketed bonnet joints under elevated temperatures. The story behind the development of the Edward leak-proof Univalve* (sizes to 2½" in 1500, 2500 and 4500 lb. pressure classes) is the story of the product research that solved this industry problem.

EARLY EXPERIMENTING: Elimination of the bonnet joint entirely, by providing a one piece body-yoke construction, appeared to be a logical approach to the bonnet joint problem. But this created a new problem—how to apply and *how to service* an integral Stellited seat from a distant point at the top of the valve yoke. Some valve manufacturers chose to split the valve body near the seat and then reassemble the body with a full pressure weld. Others chose a full pressure weld at the normal bonnet joint position. Neither approach allowed the user to disassemble the valve and both approaches resulted in the sacrifice of a positive, permanent backseat—a desirable feature in any high-pressure valve. Edward engineers refused to make these concessions.

ENGINEERS FIND SOLUTION: After many attempts, Edward engineers developed a water-cooled welding torch for the application of the Stellite seat. This provided a stress-free Stellite layer of uniform density, firmly bonded to the body, free of cracks and pin hole porosity. Simultaneously, other Edward engineers sought the answer to the bonnet joint leakage problem. Extensive research and testing of a variety of body-bonnet combinations and seal-welding techniques resulted in the four elements of today's proven Univalve bonnet joint—a body-bonnet shoulder, load carrying thread, guiding section for alignment and the seal weld.

NEW DESIGN PROVES OUT: Months of research testing failed to find a weakness in the new design. Thousands of operations at rated pressure and temperature indicated long-time seat tightness superior to anything previously achieved. Bonnet joint design could not be made to fail at several times the valve rating. Tests were conducted with supercritical steam pressures up to 6000 psi at 1050 F in the only known facilities capable of producing those conditions at that time. And, to date, *hundreds of thousands of Univalves are in service with only one recorded instance of bonnet joint leakage*—a minor defect in the seal weld.

Edward builds a complete line of forged and cast steel valves from ¼" to 18", in globe and angle stop, gate, non-return, check, blow-off, stop-check, relief, hydraulic, instrument, gage and special designs for pressures up to 10,000 lbs. For more detailed information, contact your Edward Representative, or write Edward Valves, Inc., 1202 West 145th Street, East Chicago, Indiana. Subsidiary of Rockwell Manufacturing Company. Represented in Canada by Lytle Engineering Specialties, Ltd., 438 St. Peter Street, Montreal.

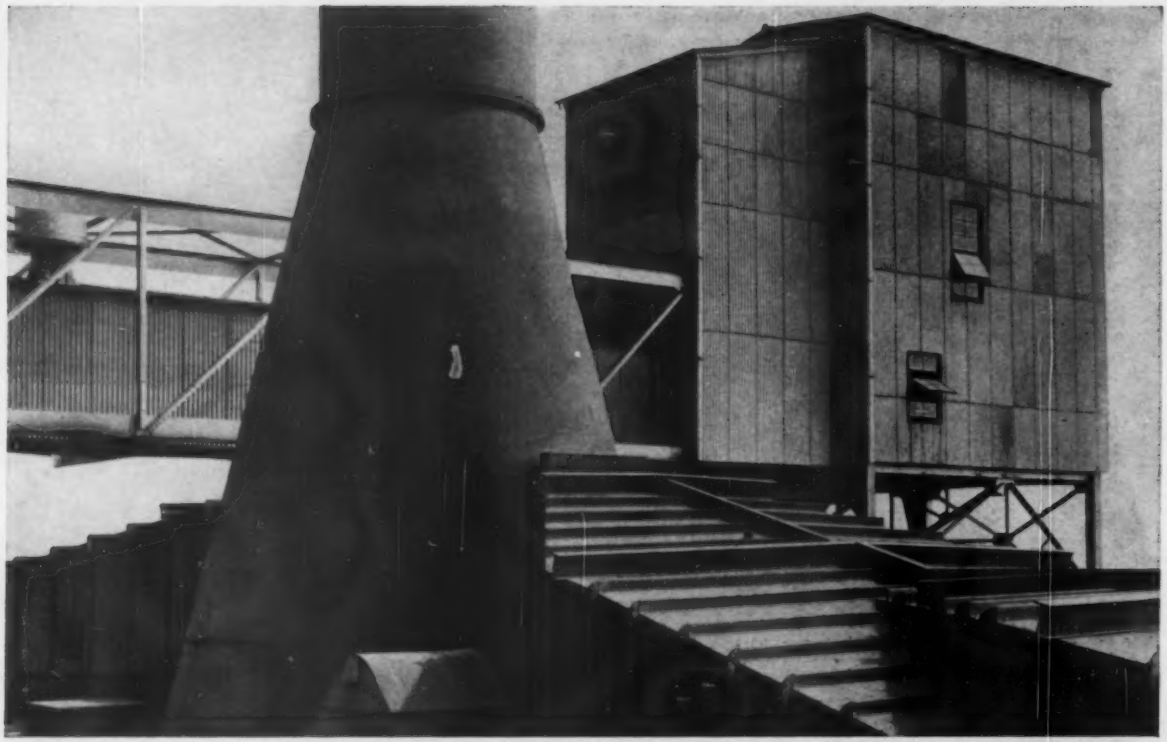
EDWARD STEEL VALVES
another fine product by
ROCKWELL

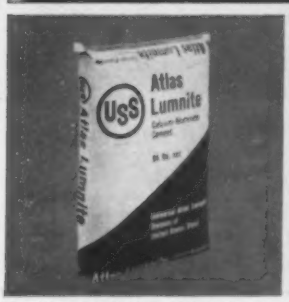
◀ **E. A. STICHA,** Chief Research Metallurgist, and R. K. Wagenblast, Research Engineer, measure temperature of valve seal weld in superheater test loop used in Univalve research.

▼ **DESTRUCTION TESTS IN EDWARD LABORATORIES IN EARLY 1940's**—Bonnet seal weld (A) of test valve cracked only after body creep occurred at 200° F above primary temperature and four times the primary pressure.

CRITICAL LEAKAGE PROBLEMS ATTACKED BY EDWARD RESEARCH ENGINEERS—(A) Bonnet leakage solved by design featuring threaded structural joint and seal weld; (B) Seat leakage solved by revolutionary Stellite seat welding technique.

*T.M. Reg. U.S. Pat. Off.





Guniting of stacks and breechings at Ohio Edison Company, Shadyside, Ohio. **Contractor: Gunite Concrete & Construction Co., Kansas City.**

Protect steel stacks with corrosion-resistant concrete

Another stack and breeching is being protected with corrosion-resistant concrete linings made with LUMNITE calcium-aluminate cement and suitable aggregates. This lining will resist the corrosive action of flu-gas condensate that forms on stack interiors. Insulation is added, too. Monolithic concrete linings keep stack gases hot, help maintain better draft for greater operating efficiency. In addition, there is less tendency for gases to reach dew-point. And the steel shell stays cool, prolonging the life of exterior paints. Gunited or plastered, installation is fast, easy, economical. The concrete reaches service strength within 24 hours. For greater convenience, manufacturers of refractories offer castables bonded with LUMNITE cement – packaged mixtures ready to use with just the addition of water. For more information, write Universal Atlas Cement, 100 Park Avenue, New York 17, N. Y.

L-203

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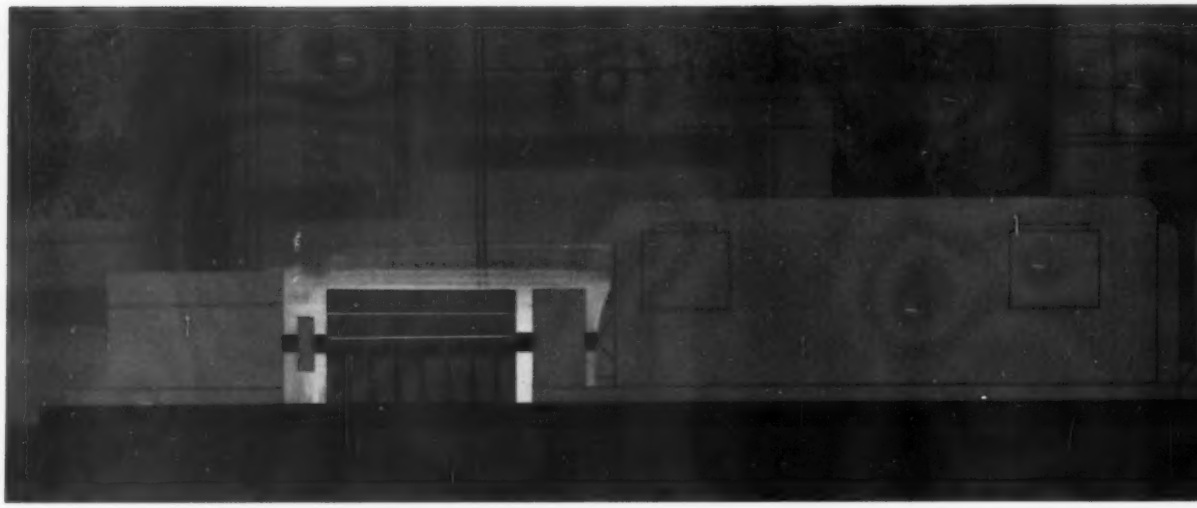
Universal Atlas Cement
Division of
United States Steel

Offices: Albany · Birmingham · Boston · Chicago · Dayton · Kansas City · Milwaukee · Minneapolis · New York · Philadelphia · Pittsburgh · St. Louis · Waco

For more data circle 510 on Post Card

American-Standard Industrial Division POWER-LIFT IN ACTION

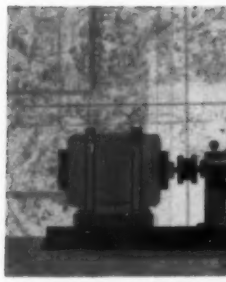
Gýrol® Fluid Drive
proved record of fi



On-the-shaft Fluid Drive applications offer multiple savings. In addition to the well-known savings which adjustable speed offers, main shaft driven pumps eliminate costly electrical accessories necessary for motor driven pumps. Auxiliary demands are reduced, so more power can be released to consumer lines.

"On-the-Shaft" Gýrol Fluid Drives
installed, or to be installed,
for the following public utilities:

Consolidated Edison of New York, Inc.
Public Service Electric & Gas Co.
Pacific Gas & Electric Co.
Louisiana Power & Light Co.
Southern California Edison Co.
Consumers Power Co.
Commonwealth Edison Co.



On motor driv
advantages of Fluid D
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adjustable speed savin
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Fluid Drive provides f
rating to shutoff. Ope

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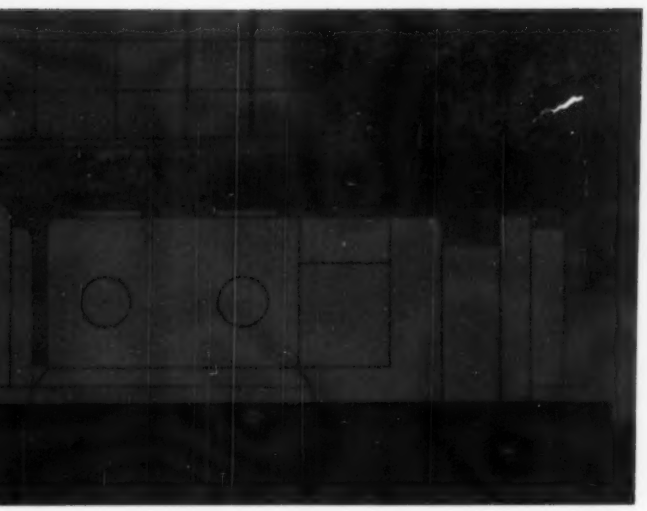
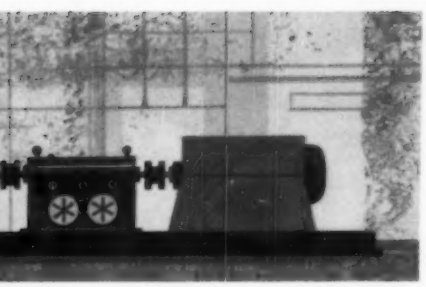
field experience and reliability

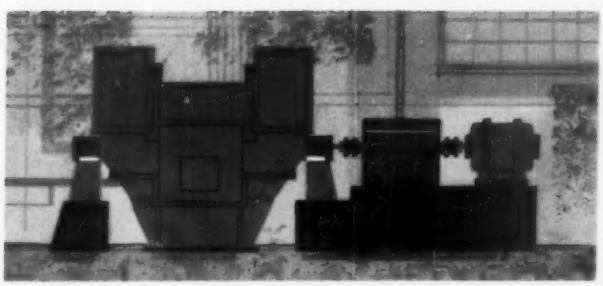


Today more than 4-million horsepower are being driven through Gýrol Fluid Drives in public utilities, industrial power plants, and on industrial machinery of all types. Such widespread acceptance could only come from proved performance in the field.

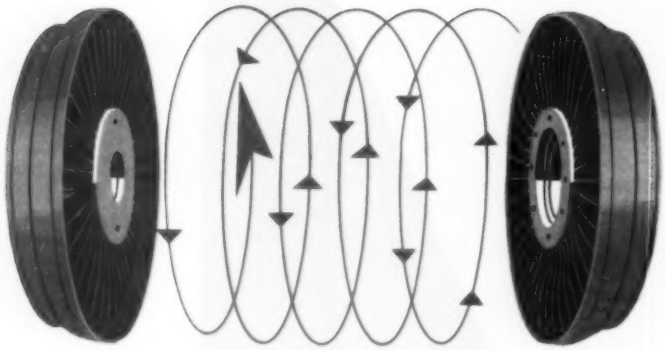
In power plant applications, not only does Gýrol Fluid Drive's stepless, shockless, adjustable speed pay off in better control, lower maintenance costs and reduced noise levels, but it also provides substantial power savings through lower horsepower requirements.



lriven boiler feed pumps the uid Drive have been proved in hundreds er the past 20 years. Through Fluid Drive, savings in pump horsepower are obtained tual operating range. In many cases elimier regulating valves and lower initial costs heaters, piping and fittings are effected. ides fast, accurate control from full pump Operators like this full-range flexibility.



Fluid Drive on Mechanical Draft Fans. Present day boilers are demanding larger fans requiring higher horsepower and higher speed motors. Problems of high fan WR^2 starting, of fan noise and of fan control are of increasing concern. Fluid Drive provides a better means of driving and controlling today's mechanical draft fans. Fluid Drive can divorce fan from motor for starting. Through adjustable speed Fluid Drive can lower fan noise, reduce fan wear, and save fan horsepower.



New from American-Standard
Industrial Division

Power-Lift† for Power Plants

cuts auxiliary demand with Gýrol® Fluid Drive

Power-Lift is a timely new concept of coordinated products and services from American-Standard Industrial Division. Its purpose is to help you raise overall efficiency in your plant by offering *products* that are proved in the field and designed, engineered, and manufactured to a uniform standard of quality and performance . . . with *service* by product specialists in every principal city.

← **LIFT THE FLAP** *and see how Gýrol Fluid Drives provide cost-saving benefits for fans and boiler feed pumps . . .*

†Service-mark of American-Standard

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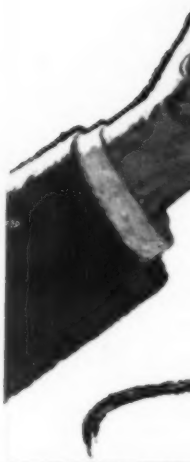


SURFACE C

Designed to ser today's and tom bines. Low b velocity; liberal tion lanes; mois grids to extend t diaphragms; effe and many other during 40 years denser developm

HEAT EXC

Designed and bu ness and precisi specially engineer ally all conditions including high p perature exchan inter- and after heaters, blow-d and many others

As Near as Your Phone

American-Standard Industrial Division
Power-Lift Products and Services

Talk over your requirements with an American-Standard* Industrial Division product specialist. You'll find him well prepared and experienced—frequently able to base equipment recommendations upon precedents of proved success. And, in many instances, our comprehensive standardization paves the way to savings in time and cost. Offices in all principal cities. AMERICAN-STANDARD INDUSTRIAL DIVISION, DETROIT 32, MICHIGAN. IN CANADA: AMERICAN-STANDARD PRODUCTS (CANADA) LIMITED, TORONTO, ONTARIO. EXPORT DIVISION, AMERICAN-STANDARD, NEW YORK CITY.

CE CONDENSERS

o service the largest of
d tomorrow's steam tur-
w bundle entrance
beral steam transporta-
moisture impingement
end tube life; expansion
; effective de-aeration
other features created
years of surface con-
elopment and research.

MECHANICAL DRAFT FANS

Complete range of sizes and types for forced draft, induced draft, gas recirculating, and primary air fan applications. Designed to meet rigid requirements of modern power plants where maximum pounds of steam are produced daily at peak efficiency. Airfoil, forward curved, backwardly inclined, radial, radial tip blades.

FEEDWATER HEATERS

Design incorporates unique new High Pressure closure. Maintenance is simplified with only four major parts. Exceptionally high safety factor built into all units—more than double ASME Code requirements. Temperature stresses from start-ups or load changes virtually non-existent.

EXCHANGERS

nd built with thorough-
precision. Standard or
gineered units for virtu-
itions and applications,
igh pressure-high tem-
xchangers, compressor
after-coolers, fuel oil
ow-down exchangers,
thers.

GYROL® FLUID DRIVE

Provides stepless adjustable speed control for fans and boiler feed pumps. Performance, power savings, and reliability proved in the field. Units for motor driven boiler feed pumps or for "on-the-shaft" duty on main turbine generator. Drives are available for fan and pump duties for all boiler sizes.

DUST AND FLY ASH COLLECTORS

Type "D" Dust Collector: mechanical "cyclone-type" collector. Series 342 Dust Collector: uses "cyclone" principle, with individual tubes which permit flexibility in design to fit plant layout. Series 361 Dust Collector: combines primary and secondary systems for high efficiency fly ash recovery.

*American-Standard and Standard® are trademarks of American Radiator & Standard Sanitary Corporation.

AMERICAN-Standard
INDUSTRIAL DIVISION

AMERICAN BLOWER PRODUCTS • ROSS PRODUCTS • KEWANEE PRODUCTS

U. P. GENERATING COMPANY FOUND A WAY TO BE SURE OF CHOOSING THE RIGHT TURBINE OIL

They selected NONPAREIL —the only oil with life-of-turbine guarantee

Situation: In 1955, Upper Peninsula Generating Company installed a 22,000 kw General Electric turbine in its Presque Isle station. When lubricant for this turbine was chosen, U. P. management elected to install an oil with a life-of-turbine guarantee—NONPAREIL.

But that wasn't all plant management received when the decision was made to buy NONPAREIL Turbine Oil. In addition, Duane Johnson, Standard Oil lubrication specialist located in Marquette, made a complete lubrication survey of the entire plant. He provided technical service on lubrication during construction and after operations started.

What has happened: In the four years since installation, the turbine has performed satisfactorily without any lubrication difficulty. In a routine inspection a year after installation, the bearings proved to be in excellent condition. Periodically samples of the oil have been removed for analysis at Standard Oil's Whiting laboratory. The oil remains in its original excellent condition.

What you can do: Get this life-of-turbine guarantee on the turbine oil you install by specifying NONPAREIL. Call the lubrication specialist in the Standard Oil office near you anywhere in the 15 Midwest or Rocky Mountain states. Or contact **Standard Oil Company (Indiana), 910 South Michigan Avenue, Chicago 80, Illinois.**

You expect more from STANDARD *and you get it!*

Standard Oil lubrication specialist Duane Johnson (left) and station chief engineer Charles York, inspect 22,000 kw G-E turbine at Presque Isle station. On lubrication jobs of this kind Duane Johnson is well qualified to provide technical service. He has an engineering degree from the Michigan College of Mining and Technology plus 10 years' experience with Standard in this work. He has also completed Standard's Sales Engineering School.

Quick facts about
NONPAREIL
TURBINE OIL

- Will not permit formation of harmful acids
- Will not permit formation of sludge or oil varnish
- Will maintain good demulsibility or water-separating characteristics
- Has high resistance to foaming
- Contains adequate rust inhibitor

WHAT REPUBLIC'S TEN COMBUSTION CONTROL

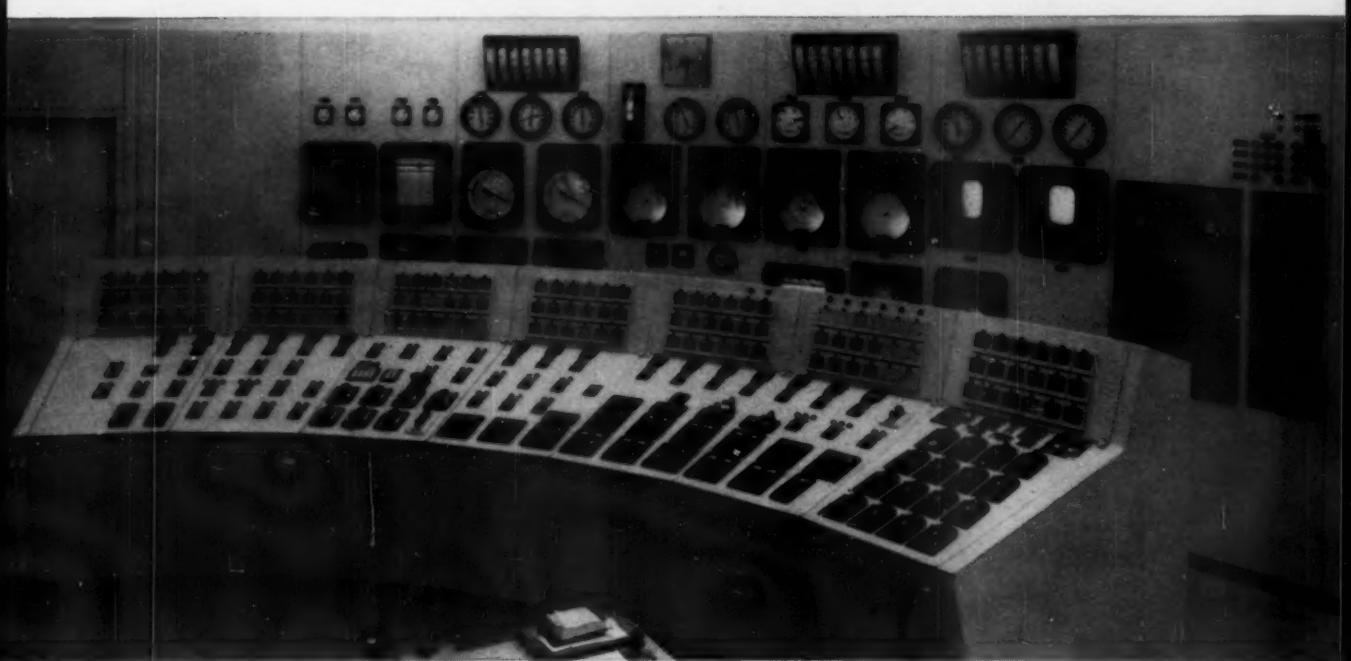
In the last ten years, Republic Flow Meters has designed over 125 electronic combustion control systems for steam generating plants. Republic has over 400 unit-years experience

1949—The first electronic combustion control system was designed by Republic and installed at Commonwealth Edison's 640,000 KW Ridgeland Station near Chicago. To maintain maximum firing efficiency, 28 cyclone furnaces are individually controlled and integrated with over-all plant operation by a Republic Electronic Combustion Control System.

Leading manufacturer of electronic combustion control

YEARS OF ELECTRONIC LEADERSHIP MEANS TO YOU

with electronic combustion control installations ready to go to work on your system. This is engineering know-how you get only from Republic Flow Meters.



1959—This Republic Electronic Control System, one of the most recent to be put into service, is for 121,000 KW, unit No. 1 at the Paul L. Bartow Station of Florida Power Corporation, St. Petersburg, Florida. It controls a 900,000 lb/hr oil and natural gas boiler. Republic is currently engineering an electronic control system for unit No. 2 in this plant.

REPUBLIC FLOW METERS COMPANY
2240 Diversey Parkway • Chicago 47, Illinois
In Canada: Republic Flow Meters Canada, Ltd., Toronto
Subsidiary of Rockwell Manufacturing Company

REPUBLIC INSTRUMENTS AND CONTROLS
more fine products by
ROCKWELL

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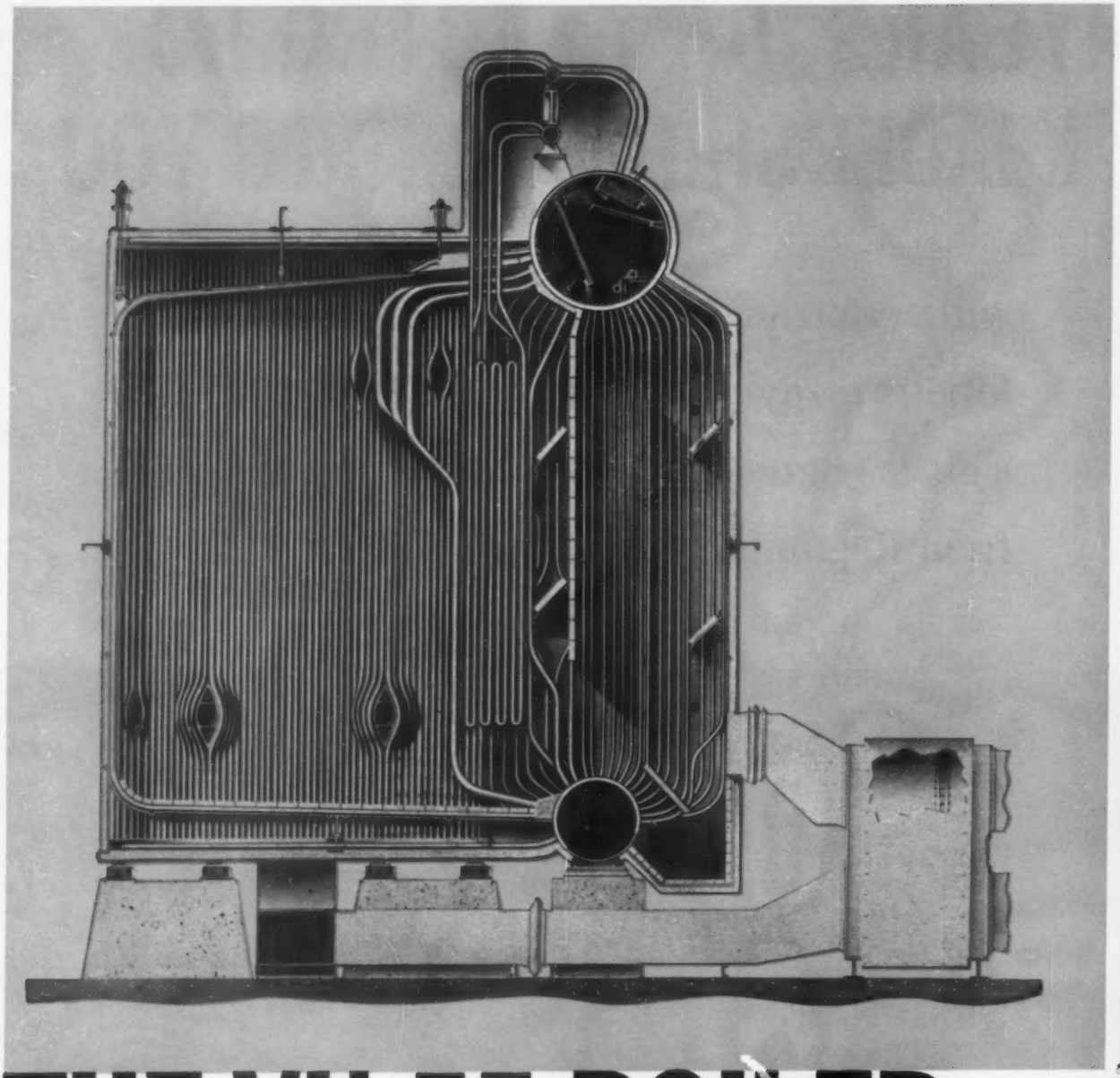


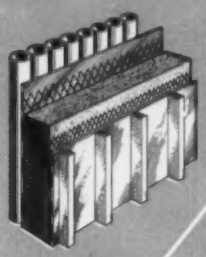
THE VU-55 BOILER...

The C-E Vertical-Unit Boiler, Type VU-55, is designed to bring central station type of performance to the "standardized" boiler market.

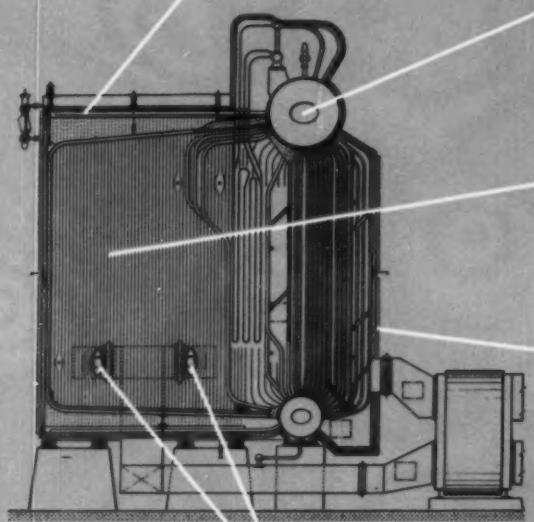
It combines a number of time-tested and service-proved features such as Tangential Burners, pressure-tight casing and tangent furnace tubes. This bottom-supported unit requires no outside supporting steel, is economical of space and has an uncluttered, streamlined appearance.

The VU-55 is available from 70,000 to 150,000 lb of steam per hour. It is designed for three pressure ranges (250, 500 and 750 psi) and can be equipped with a superheater to provide temperatures up to 800 F.

ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT; NUCLEAR REACTORS;



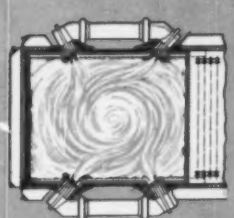
PRESSURE-TIGHT, SKIN CASING. A service-proved method of casing construction for pressure-fired boilers in the size class of the VU-55, this casing is designed to assure life-time tightness with minimum heat loss. Pressure firing permits the elimination of an induced draft fan with its attendant operating and maintenance costs. Wall construction consists of tangent tubes backed up successively with welded steel panels, 4 inches of high quality insulating material and an outer steel casing formed as shown to provide adequately for expansion and to give a neat, finished appearance.



HIGH STEAM QUALITY. The VU-55 has generous water capacity and steam reservoir space. Its drum internals are exceptionally effective in producing high quality steam at all ratings.

TANGENT FURNACE TUBES. The VU-55's furnace tube arrangement provides complete heat-absorbing, water-cooled protection on all furnace walls. Furnace maintenance is minimized, refractory expense is eliminated.

STREAMLINED EXTERIOR. The over-all appearance of the VU-55 reflects the efforts of its designers to achieve a completely unobstructed casing, while retaining adequate access wherever required and every facility for convenient operation. There are no outside downcomer tubes, and the ducts from air heater to burners are beneath the furnace floor.



TANGENTIAL FIRING. More than 20 years of application experience have established the exceptional advantages of tangential firing. About 90 percent of Combustion's large utility installations use this advanced method of firing. Flame streams from the four burners impinge upon one another at high velocity, as shown, creating a turbulence unattainable by any other method of firing. The result is rapid and complete combustion. As the gases spiral upward, they sweep all furnace heating surfaces, assuring a high rate of heat absorption.

a "standardized" boiler with "custom-built" performance

The unit is symmetrical in design, performs efficiently over a wide range of output, and is exceptionally easy to operate and maintain.

When you are considering additional steam capacity in the quantity range mentioned above don't fail to investigate the advantages of the VU-55.

COMBUSTION ENGINEERING

C-E

C-261

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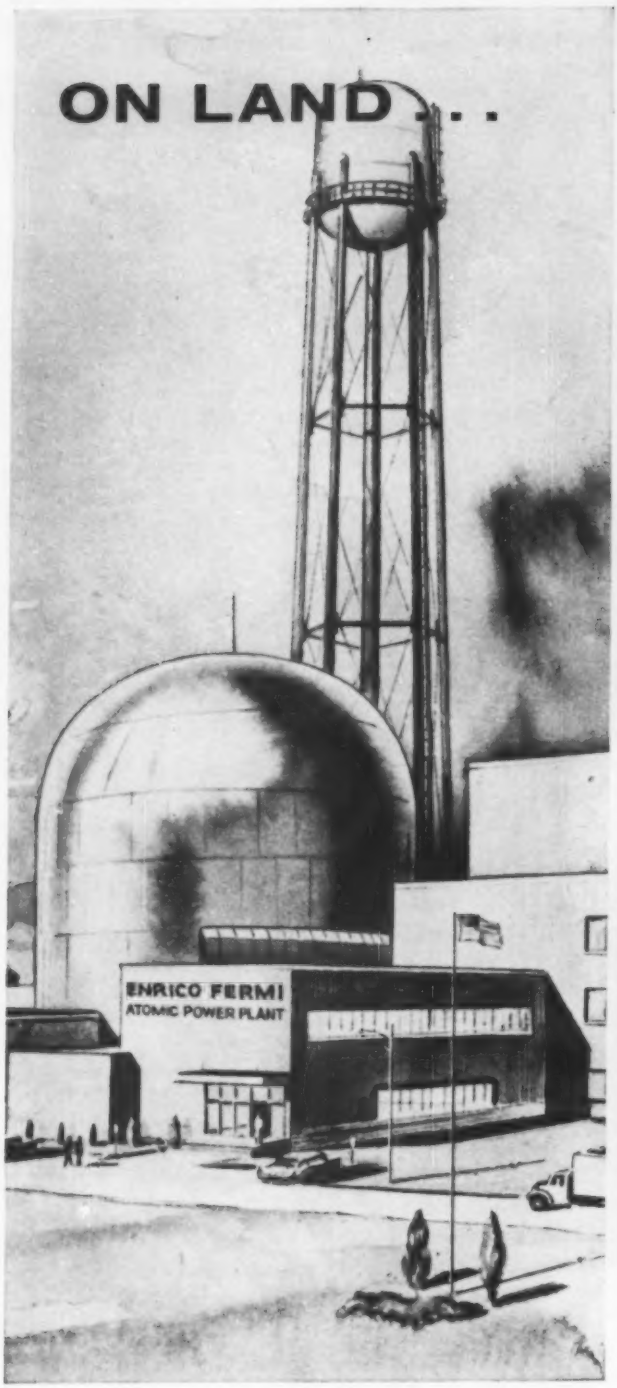
PAPER MILL EQUIPMENT; PULVERIZERS; FLASH DRYING SYSTEMS; PRESSURE VESSELS; SOIL PIPE

For more data circle 514 on Post Card

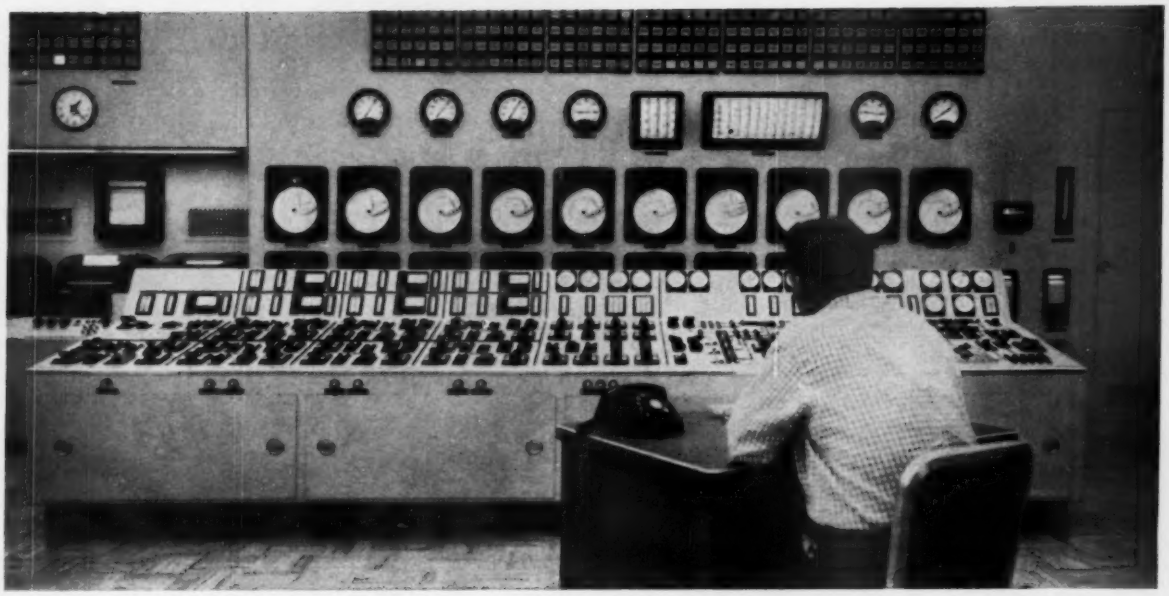


At the Enrico Fermi Atomic Power Plant, instruments and controls for both the "fast neutron breeder" reactor and the steam plant which it will "fire" are being furnished by Bailey.

Many of the new ships such as this super-carrier, USS Ranger, operate their boilers by Bailey Meter Control. Cargo ships, tankers, and passenger liners as well as Naval ships improve the economy and safety of their steam plants thru use of Bailey controls.

At the Thomas H. Allen Electric Generating Station of the City of Memphis, Tenn., Bailey operating indicators and controls for combustion, feed water, and steam temperature are centralized on the mechanical bench-board directly ahead, while the operating records which reflect trends are mounted on the vertical boards. A Bailey METROTYPE Information System, center left in the photo, scans, monitors, and logs functions usually assigned to strip-chart recorders.

IT'S BAILEY. . .



for the latest and safest instruments and controls for nuclear and conventional power plants!

Many of the power plants of the future will have controls and instruments designed and built by Bailey. There are two reasons: Bailey's continuing research and development toward the latest equipment for industry's needs; Bailey's 40-year association with the hardware and economic requirements of the industry.

If you are planning new or improved power plant facilities, call on Bailey engineers to assure that your system will have the *proper balance both as to economics and needs . . . that there will not be the unnecessary expense of over-instrumentation or control . . . nor the duplication of equipment functions.*

Call on Bailey for primary sensing devices, indicators, loggers, control units, panels, data handling equipment, computers for performance analysis, and supervisory controls. You'll find designs ranging from conventional to the most sophisticated . . . mechanical, pneumatic, electric and electronic, including solid state.

There's a Bailey District Office or Resident Engineer close to you. Check your phone book, or write direct.

A144-2

Instruments and controls for power and process

BAILEY METER COMPANY

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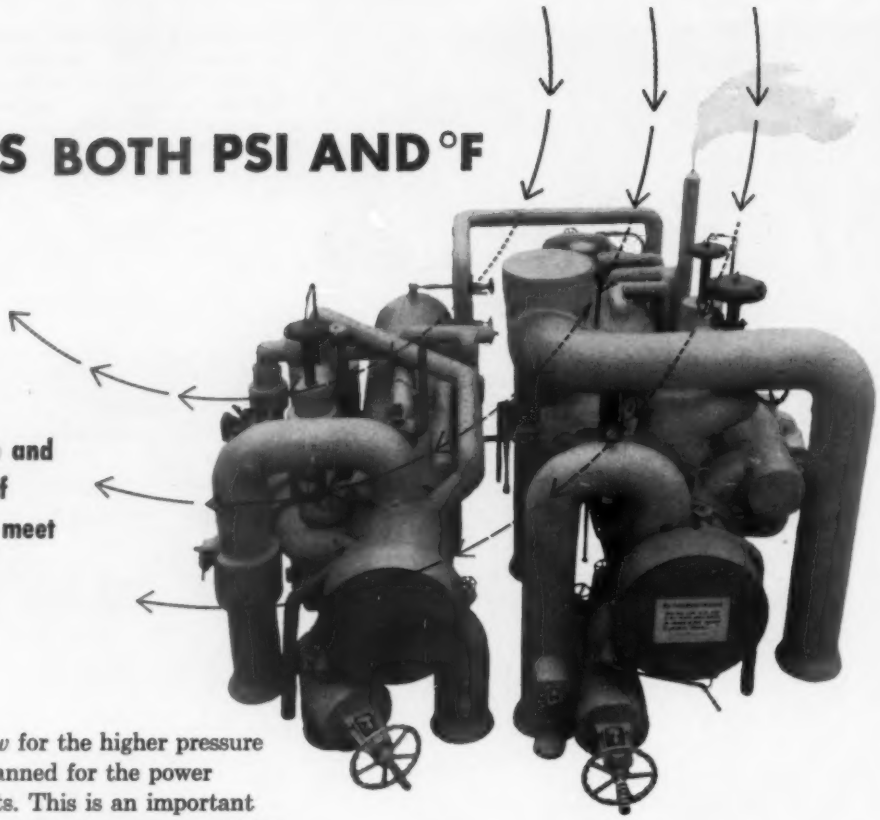
YUBA LICKS BOTH PSI AND °F



Exclusive Multilok Closure and all-welded construction of Yuba Feedwater Heaters meet requirements of newer generating stations

Yuba has the products *now* for the higher pressure and temperature ranges planned for the power industry's new steam plants. This is an important reason why Yuba Feedwater Heaters are so widely specified throughout the industry today. Operating in the 4,000 PSI, 1,000 °F range now, Yuba Feedwater Heaters, incorporating the exclusive *Multilok Closure*, are suited for all future pressure and temperature developments.

Advanced engineering keeps Yuba ahead . . . the new *all-welded construction*, for example. Shells are welded to channels without flanges, eliminating possible leakage that can occur in other construction at high pressures and temperatures. For low and intermediate pressures, Yuba's bolted design is applicable.

When space is important, Yuba can combine several heaters—effectively designing two or more stages in a single shell. For all your needs, Yuba specialists will discuss with you in detail, the design, construction and advantages of Yuba's *years ahead* Feedwater Heaters.

Other Yuba products for steam power plants include Condensers, Evaporators, Expansion Joints, Heaters, Tanks, Cranes, Structural Steel and scores of other items.

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HELPFUL BULLETINS

VALVES AND PIPING

101 Check Valves — Details and specifications on check valves designed to eliminate water hammer and line surge are presented in 20-pp Catalog 600. Typical installations are illustrated, and installation data, flow chart, and pressure-temperature ratings included. Combination Pump Valve Co.

102 Hydro-Valves — Complete details on non-chattering hydro-valves for liquid service are presented in Bulletin L-100/59. Specifications, data on sizes, capacities and materials are included. J. E. Lonergan Co.

103 Ductile Iron Pipe — Properties and characteristics of ductile iron pipe combining mechanical strength of steel with the corrosion resistance of cast iron are detailed in this 20-pp bulletin. Tables list physical and metallurgical properties of ductile iron pipe, compare its corrosion resistance in various media, give specifications. James B. Clow & Sons, Inc.

PUMPS, COMPRESSORS

104 Pumps and Controls — Bulletin 220 contains 72 pp of data on design details and operating characteristics of company's hydraulic pumps, fluid motors and valves. Sections are devoted to various types of hydraulic pumps, pumping units, fluid motors, and control valves, covering design and operating characteristics of components involved, with cutaway illustrations and tables of performance data. Denison Engineering Div., American Brake Shoe Co.

105 Positive Displacement Pump — Bulletin Ref. No. 1331 describes a low-cost, positive displacement pump for feeding concentrated corrosive chemicals. List of chemicals fed by pump, features and flow diagram of typical installation are included. B-I-F Industries, Inc.

106 Close-Coupled Pumps — Catalog D-101 describes close-coupled pumps for use in any type of package equipment requiring a small pumping unit. Design advantages and construction details are outlined, and performance curves included. C. H. Wheeler Mfg. Co.

107 Controlled Volume Pump — Data Sheet D-59-1 explains how controlled volume pumps solved the problem of metering a softening agent into the distribution lines at the pumping stations serving Ft. Bliss, Texas. By incorporating an automatic stroke length adjustment which responds to changes in flow rates, this pump provides a consistent ratio of phosphate to water with varying water pumping rates — automatically and economically. Milton Roy Co.

108 Metering Pump — Details on the Servo-Gauge metering pump, a pneumatically powered and controlled unit for metering or proportioning, are presented in Bulletin P-21. Principle of operation is described, and capacity, operating characteristics, stroking rate, materials of construction and actuating power requirements listed. Associated Control Equipment, Inc.

109 Controlled Volume Pumps — Bulletin 1158 describes company's diaphragm slurry pump for controlled volume pumping of hard-to-handle slurries and solutions. Operation details are shown through cutaway diagrams, and specifications and applications data included. Milton Roy Co.

New and revised publications reviewed on these pages offer help on operating and maintenance problems. To order, use the handy Reader Service Cards provided on pages 117 and 118.

110 Metering Pumps — Illustrated and described in 28-pp Catalog 59 are pumps designed for pumping problems where hard-to-handle chemicals or accurate metering are involved. Includes information on types of difficult fluids which the pump can handle, operation details (with drawings), and various types of reagent heads available, as well as photos, data on auto-pneumatic and electronic controls, capacity tables and specifications, Process Equipment Div., Lapp Insulator Co., Inc.

111 Stationary Compressor — Bulletin A-72, 24 pp, describes company's WN-114 stationary air compressor offering simplified installation through package design. Includes specifications on three basic models of the semi-radially constructed units ranging from 1385 to 1948 cfm at 125 psi. Design components, intercooling, lubrication, motor mountings and accessories are illustrated and explained. Joy Mfg. Co.

112 Gas-Engine-Driven Compressors — Six-pp Bulletin 179 describes design features and advantages of company's turbocharged gas-engine-driven compressors. Cutaway view showing construction details is included, and detailed dimensions and specifications. Clark Bros. Co.

WATER CONDITIONING

113 Water Treatment Control — Methods for automatic control of water treatment plants are discussed in 8-pp Technical Reprint T-179. In two parts, Part I deals with control of demineralization plants and covers a wide range of subjects including "stepless" regeneration, quality control of effluent, conductivity pH control, automatic regeneration. Part II considers control of cold process softening and clarification units, hot process-hot zeolite systems and sodium zeolite systems. Graver Water Conditioning Co.

114 Ultrapure Feedwater — Technical Reprint T-178 covers research problems relating to production and quality control of ultrapure feedwater for Eddystone Station. Presents pilot plant data on filtration and demineralization process for treating condensate and specific plant-scale design features based on the data are described, as well as analytic methods for measuring quality of condensate. Graver Water Conditioning Co.

115 How Corrosion Attacks — This water conditioning data sheet explains how and why boiler, cooling and process water systems are constantly plagued by corrosion. Discusses such factors as pH, dissolved solids, temperature, flow rate, dissimilar metals, carbon dioxide. Betz Laboratories, Inc.

MECHANICAL POWER TRANSMISSION

116 Magnetic Drive — Data Sheet 4400-PRD-263 describes variable speed magnetic drives designed expressly for pump application. Shows cutaway view and includes selection charts and specifications. Electric Machinery Mfg. Co.

117 Power Transmission Equipment — Design and construction data on power transmission equipment, including variable speed pulleys, V-belts, sheaves, motor bases, countershafts, and transmission drives, are presented in 32-pp Catalog P-58. Includes ratings and dimensions, mounting diagrams, sketch of typical arrangement, tables of representative applications. Lovejoy Flexible Coupling Co.

118 Stock Chains, Sprockets — Listed in 44-pp Book 2757 are stock sizes of this company's roller chains and sprockets available for immediate delivery in major industrial areas. Key indexed for easy reference, book presents 2000 types and sizes including standard and double pitch power transmission chains, also conveyor chains and attachments and sprockets. Lists standard roller chains — single, double, triple and quadruple strand — together with heavy series roller chains, corrosion-resistant stainless steel and bronze types, others. Sprockets described include finished bore, taper lock, mandrel bore, removable segment and shear pin types. Link-Belt Co.

119 Chain and Sprockets — Roller chain and sprockets designed to meet nearly all roller chain requirements are illustrated and described in 56-pp Bulletin A691. Covering single strand, double strand, single strand heavy, double pitch drive, double pitch conveyor, double pitch conveyor with large rollers, and standard attachments, bulletin contains photos and diagrams showing construction details, complete selection data, installation information, calculation of center distances, horsepower ratings, lubrication and maintenance data. Dodge Mfg. Corp.

120 Flexible Couplings — Ten-pp Bulletin 5103 covers the full line of Sure-Flex couplings, including "juniors" with flanges of zinc alloy and large bushed couplings fitted with Sure-Grip interchangeable QD-type tapered bushings. New engineering data also given on spacer couplings with drop-center sleeve and on use of Sure-Flex couplings with a floating shaft to connect two shafts. T. B. Wood's Sons Co.

121 Rugged Roller Chain — This technical folder describes offset side bar roller chain designed for applications where operating conditions are severe. Full details on the chain are given as well

as drawings of its construction, tables of sizes available and sprockets to be used. Atlas Chain & Mfg. Co.

ELECTRICAL

122 Motor Control Centers — Features and advantages of company's motor control centers available in either modular units or panel mounted model are detailed in 16-pp Descriptive Bulletin SPM-1-1159. Illustrates construction details, typical layouts and methods of figuring combinations, and includes suggested specifications. Automatic Control Co.

123 Control Panels — Selection of the right control panel for a variety of automatic materials handling systems is the subject of 12-pp Bulletin G-9. Four basic types, the "wall-in" master control panel, the floor and wall-mounted types, and the explosion-proof type are illustrated and described and schematic drawings included. Fuller Co.

124 Electrical Distribution — Comprehensive information on electrical distribution products is presented in this 60-pp catalog. Divided into three main sections covering molded case circuit breakers, individually-enclosed low-voltage power circuit breakers, and engineered products, it contains selection and application data, selection charts listing types, ratings and accessories. I-T-E Circuit Breaker Co.

125 Electrical Distribution, Control — Complete with photos, tables of specifications, pricing information, and wiring diagrams, this 155-pp reference catalog covers 30 types of products. They include circuit breaker load centers, fusible service equipment, enclosed safety switches, low voltage fuses, molded case circuit breakers, enclosed industrial breakers, wall mounted air breakers, bolted pressure contact switches, lighting and distribution panelboards, distribution switchboards, package power centers, wireways, bus duct, manual starters, drum switches, a-c magnetic contactors, magnetic starters, automatic transfer panels, other equipment. Book is available to qualified power engineers. Federal Pacific Electric Co.

126 Medium Transformers — Bulletin GEA 6108C, 32 pp, gives information on repetitive manufacture transformers, 501-5000 kva, single-phase, and 501-10,000 kva, three-phase. Construction details, accessories, features, ratings and characteristics given. Performance data and dimensions listed for all type units. General Electric Co.

127 Load Center Transformer — Drawings, dimensions, weights, performances and other data on basic units of load center transformers, along with details on standard transformer arrangements for use with switchgear and other equipment, are presented in 18-pp Bulletin 132-B. Gives data on design and construction, standard and special testing, standard and special accessories. R. E. Uptegraff Mfg. Co.

128 For Voltage Regulation — Sixteen-pp Bulletin 21B7977E describes some 23 features of company's JFR distribution regulators which promote more economical and better voltage distribution. Among these are savings in height and weight for greater mounting versatility, new sight indicator for fast oil level check, unit constructions. Fully illustrated, booklet includes specifications and available ratings. Allis-Chalmers Mfg. Co.

129 Wire and Cable Data — These composite, color-coded data sheets contain information formerly found only in many catalogs on wires, cables and power cords. Lists prices, stranding, strand diameters, temperature ratings, weights, overall diameters, and detailed specifications. Continental Copper & Steel Industries, Inc.

130 Rubber-Jacketed Cord — Illustrated and described in this product bulletin is a line of rubber jacketed portable electrical cord. Construction details and advantages are detailed. Western Insulated Wire Co.

131 Motor-Generator Chargers — Operation and maintenance procedures for automatically controlled vertical motor-generator chargers for lead-acid storage batteries are provided in 8-pp Form 5845. Contains instructions on day-by-day operation and long-range preventive maintenance of equipment, installation data and wiring diagrams. Exide Industrial Div., The Electric Storage Battery Co.

132 Battery Chargers — Selenium or silicon rectifier battery chargers designed for charging station-type batteries used by utilities and industrial plants are described in this product bulletin. Specifications, data and descriptions of standard models ranging from 15- to 200-amp capacity included. Syntron Co.

133 Channel, Fittings, Hangers — This pocket-size reference type work manual, about 68 pp, contains product illustrations and correlated information for specifying and using structural support materials for electrical installations. It is indexed to sections identified with specific areas of applications . . . as for suspending single and multiple runs of conduits; building racks and frames; concrete inserts; beam clamps for fastening to structures; brackets and supports; fluorescent fixture supports. A section is devoted to engineering information on product use and design. Tables show strength of sectional units, deflections and load bearing capacities. Also included are rigid conduit data, hanger rod properties, standard pipe data, and formulas for computing hanger spacing. Steel City Electric Co.

134 Cast-Aluminum Housings — Design information, detailed drawings, photos and dimension charts on a line of cast-aluminum, explosion-proof housings are presented in 16-pp Bulletin 160. Also covered are special explosion-proof housings and fittings, as well as explosion-proof and dust-tight housings with glass windows for instruments and meters. The Adalet Mfg. Co.

135 Switch Cubicle — Bulletin 18X 9442, 14 pp, describes high voltage switch cubicles to house a frame-mounted, manually-operated load-break switch incorporating function of a disconnecting switch and circuit interrupter. Discusses operation and maintenance of the load-break switch suitable for transformer primary switching in unit substations, service enterance switching, throw-over from preferred to emergency circuits, loop circuit sectionalizing and isolating plant feeders. Allis-Chalmers Mfg. Co.

MATERIALS HANDLING

136 Screw Conveyors — Comprehensive information on applications and selection of screw conveyors, screw feeders, and components is presented in 78-pp Book 2989. Contains descriptive sections on screw conveyors and their uses, types of components, engineering of screw conveyors, screw feeders, components, dimensional data, and lists materials for which conveyors may be used. Link-Belt Co.

137 Vibrating Feeders — Twelve-pp Book 2869 illustrates and describes motorized counterweight vibrating feeders designed to handle a wide range of bulk materials. Selection and application information is included, as well as illustrations of possible applications, and a chart showing variations possible in cable suspension or floor mountings. Link-Belt Co.

138 Car Shaker — Advantages of a 3½-ton car shaker for fast, safe, economical, pushbutton unloading of granular material from open, hopper-bottom gondola cars, are given in Bulletin 26B9438. This shaker is designed for plants where unloading of hopper-bottom cars does not warrant installation of a 5-ton unit and where smaller capital investment is desirable. Allis-Chalmers Mfg. Co.

BOILERS

139 Packaged Boilers — Design features and advantages of company's line of packaged boilers and high temperature equipment for heating and pressure loads are detailed in this 8-pp bulletin. Specifications, ratings and dimensions, and recommended boiler room layouts are included. Cleaver-Brooks Co.

140 Automatic Boilers — Design features and advantages of automatic boilers which combine higher heat exchange with maximum radiant heat absorption are illustrated and described in this product bulletin. Dimensions and data table included. Continental Boiler Div., Boiler Engineering & Supply Co., Inc.

141 Packaged Boilers — Form 1145 describes forced draft square-heat packaged boiler-burner units for oil, gas or combination firing. Illustrated with photographs and line drawings, this bulletin contains ratings, dimensions and technical data. Also included are specifications and a list of standard accessories. Industrial Div., American-Standard.

INSTRUMENTS AND CONTROLS

142 Nuclear Instrumentation — Detailed information on nuclear instrumentation and accessories is presented in 50-pp Condensed Catalog F. Covers all phases of nuclear study and includes detectors, counting and radiation analysis equipment, sample changing equipment and all necessary adjuncts for personnel protection, monitoring and handling. Tracerlab, Inc.

143 Multi-Pointer Gages — Product Specification M42-2 describes multi-pointer gage units designed for pressure and level measurements, and pneumatic transmitting or receiving. Describes features and physical characteristics, and includes specifications and mounting dimensions. Bailey Meter Co.

144 Mineral Insulated Thermocouples — Features and advantages of mineral insulated thermocouples are detailed in 20-pp Catalog 300. Includes detailed specifications for ordering complete

CLEARWATER FINISHING
GETS SAVINGS
WITH INTEREST,
USING A

PACKAGE AIR PREHEATER

Fuel savings alone pay for it in two years; installation costs cut by pre-assembly — —

Savings come in pairs at Clearwater Finishing Co., with the installation of their new Package Air Preheater. This is why:

1. Initial savings on installation. You can install a Package Air Preheater at a fraction of the expense required for conventional heat recovery equipment. The unit you see in the picture is a *complete* Package Air Preheater. To put it into service you simply lift it into place, make power and duct connections. It's that fast, that easy.

2. Long term fuel savings . . . $17,000 a year off your fuel bill (more or less, depending on size of preheater and application). What you save on fuel can pay for the Package Air Preheater within two years.

Installation savings are achieved through standardized design, which permits complete shop assembly. Fuel savings are achieved through the efficient continuous regenerative heat recovery principle, which cuts your fuel bill 1% for each 45-50°F increase in preheated air temperature.

For application ideas, and facts and figures on the potential savings, write for free 14-page booklet.

Completely pre-assembled Package Air Preheater is lifted into place at the new plant of Clearwater Finishing, (Division of United Merchants & Manufacturers, Inc.) at Clearwater, South Carolina. Installed at far less cost than a unit requiring on-site erection, this Package Air Preheater will serve a 83,000 lb/hr boiler. It measures approximately 8'x8'x6', and its 4900 sq ft of effective heating surface will recover 290°F from the stack gas.

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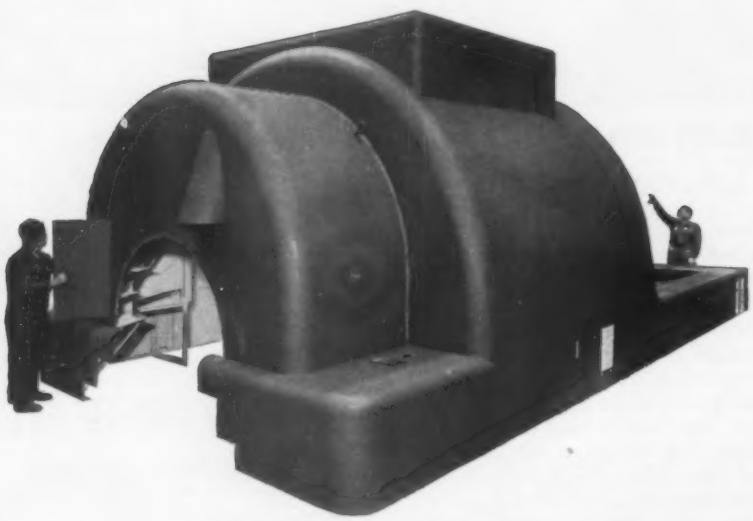

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assemblies, as well as data on hot junctions, terminations and mounting methods, all of the products correlated into company's ordering number system for simplified ordering. Conax Corp.

145 Condensate Flow Regulator — Bulletin 600 describes a low-cost condensate flow regulator that operates without moving parts. Advantages are detailed and typical installation is diagrammed. Stickle Steam Specialties Co.

146 Recorder/Reproducer — Digital magnetic-tape recorder/reproducer systems designed to meet a broad range of computer, industrial and other requirements are described in Bulletin 1618. Operating characteristics and specifications are included. Consolidated Electrodynamics Corp.

147 Boiler Control — Twelve-pp Bulletin 1065 describes boiler control on an all-outdoors municipal lighting plant. A comprehensive schematic diagram shows control circuits. Copes-Vulcan Div., Blaw-Knox Co.

148 Industrial pH Amplifier — Data Sheet EIL 28AM explains and illustrates company's Model 28 AM industrial pH meter, a line-connected instrument specifically engineered for the measurement of pH in industrial manufacturing processes. Specifications are given. Milton Roy Co.

149 Positioning, Program Controls — Bulletin J-105, 16 pp, features an expanded line of linear and rotary actuators; six basic types of remote positioners; machine tool point-to-point position and rate control; punch card formula and program control; closed loop process control. Provides descriptive and application information, specifications, dimensional drawings. Jordan Controls, Inc.

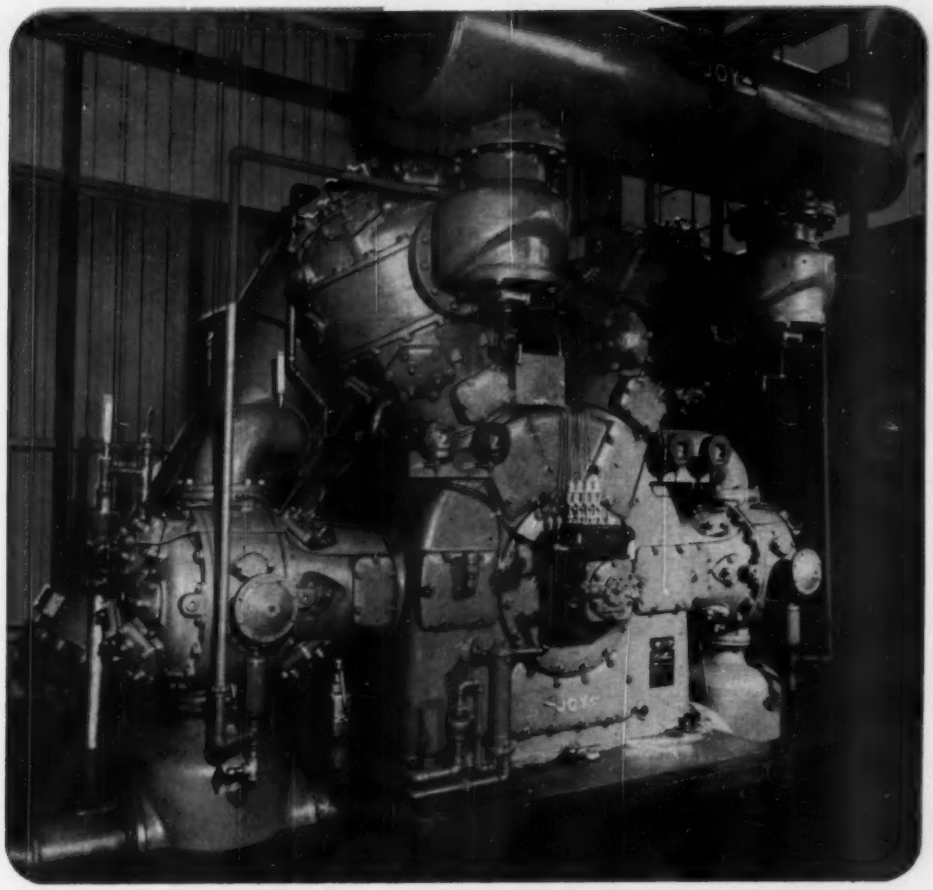
DUST CONTROL

150 Dust Collectors — Included in 16-pp Bulletin 1828 is a list of typical industry applications . . . for power plants, steel production, cement and aggregate production, chemical and petroleum processing, food and grain processing and general manufacturing. Covers operating characteristics, construction features, and includes nomogram presentations designed to simplify engineering calculations, assembly arrangements, line drawings, dimensional and physical data. American-Standard.

151 Freedom from Dust — Bulletin 805, 28 pp, describes a variety of dry collection equipment, showing ways of using cloth filtration and cyclonic equipment for eliminating dust control and air pollution problems. Features descriptive information and specifications on the Multi-Bag filter, Uni-Filter, Glass-Bag Filter and Whirl-Clone, also special collectors and accessories. Illustrated application data shows how industry uses these to collect waste dust or to reclaim reusable material. Dracco Div., Fuller Co.

OTHER EQUIPMENT

152 Industrial Heat Exchanger — This selection data form covers a complete line of industrial heat exchangers, including a package regenerative air preheater for industrial process or boilers in a range from 25,000 to 250,000 lb per hr; recuper-



This 350 hp WN-224 Compressor supplies plant air to a modern foundry in Indiana.

Joy Design Means:

SIMPLE BASE WHICH CUTS COMPRESSOR INSTALLATION COSTS

The semi-radial design of Joy compressors makes installation a simple and inexpensive operation. Machines are completely assembled when shipped from the factory. Installation is accomplished by securing the frame to four studs set in the rectangular concrete pad. Form work is simpler, and the complicated alignment and assembly operations necessary with other compressors are eliminated. The net result is lower installation cost for your compressors.

Joy semi-radial compressors have many other features which enable them to supply plant air at minimum cost by reducing operating and maintenance expense. Your Joy representative can supply complete details, or write for Bulletin 925-56C.

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- ☐ rust and corrosion in my brine or sweet water system
- ☐ scaled up pumps, water jackets, compressors, coils, lines, or equipment
- ☐ sludge and moisture in my fuel oil supply
- ☐ soot deposits in my furnace combustion areas

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ative type heat exchangers for high temperatures, high pressure applications where leakage cannot be tolerated; and a compact rotary regenerator. The Air Preheater Corp.

153 Air-Cooled Condensers — Four types of air-cooled condenser units are discussed in 12-pp Bulletin AC-102 — those using propeller fans for horizontal air flow, propeller fans for vertical air flow, centrifugal fans for use with ductwork, and centrifugal fans. Coil and fan data are given as are capacities in Btu per hour at evaporator, and detailed specifications. Halstead & Mitchell.

154 For Chemical Processing — Equipment presented in 12-pp Bulletin S.A1133 includes centrifuges, plate heat exchangers, screens and laboratory devices. Cross-section drawings are included to describe functional differences between six centrifuge types, and two processes, production of crude tall oil and refining vegetable oils, are described and illustrated with flow charts, De Laval Separator Co.

155 Gas Scrubbers — Illustrated and described in 12-pp Bulletin 4R are ejector-venturi scrubbers, venturi throat scrubbers, condensing scrubbers, cyclonic scrubbers and separators. Includes application, construction and operation information, dimensional data, tables of gas handling capacities and detailed performance data. Schutte and Koerting Co.

156 Multi-Arc Welding — This Technical Bulletin BL-MA101 reviews experience of users, and explains how the multi-arc principle reduces equipment requirements and simplifies installation and maintenance while producing welds of high quality. A table summarizing costs shows how multi-arc systems can save 52 per cent in power equipment. J. B. Nottingham & Co., Inc.

157 Air Cylinders — Bulletin P2547P contains 24 pp of detailed information on air cylinders, hydraulic cylinders, non-sag piston rods, high-speed cushions, adjustable stroke cylinders, air-hydraulic boosters, air-oil circuits, and Tru-Seal pipe thread fittings for eliminating positioning problems and leakage at threaded connections. Design features and advantages are illustrated, mounting and dimensional data and thrust charts included. Miller Fluid Power Div., Flick-Reedy Corp.

New and revised publications reviewed on these pages offer help on operating and maintenance problems. To order, use the Reader Service Card on page 117. When ordering catalogs, allow time for us to relay your requests to the manufacturers — and for them to mail out copies. Remember, manufacturers are often swamped with catalog requests.

158 Tube Fittings — A wealth of technical data on Hi-Seal butt-joint tube fittings for high pressure and temperature applications is presented in 48-pp Catalog 3108. There are sections on pressure, temperature, vacuum, corrosion resistance, port seals, flow and velocity characteristics along with laboratory reports and

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CENTRIFUGAL PUMP APPLICATION MANUAL

by BUFFALO PUMPS ENGINEERS

Here in concise useable form are complete facts on centrifugal pumps and their application. Quick, ready reference is provided by subject sections tabulated at the front. A wealth of illustrations and diagrams amplifies the subject matter.

The purpose of this Engineers' Handbook is to cover the various uses of Centrifugal Pumps, the different types designed to meet specific needs, their operation and the solution of pump problems. Also included are general data and Standards of the Hydraulic Institute.

The pocket-size Manual contains 277 pages of fact-filled information of vital importance to every user of pumps. It will prove an invaluable tool and reference to every Pump Engineer.

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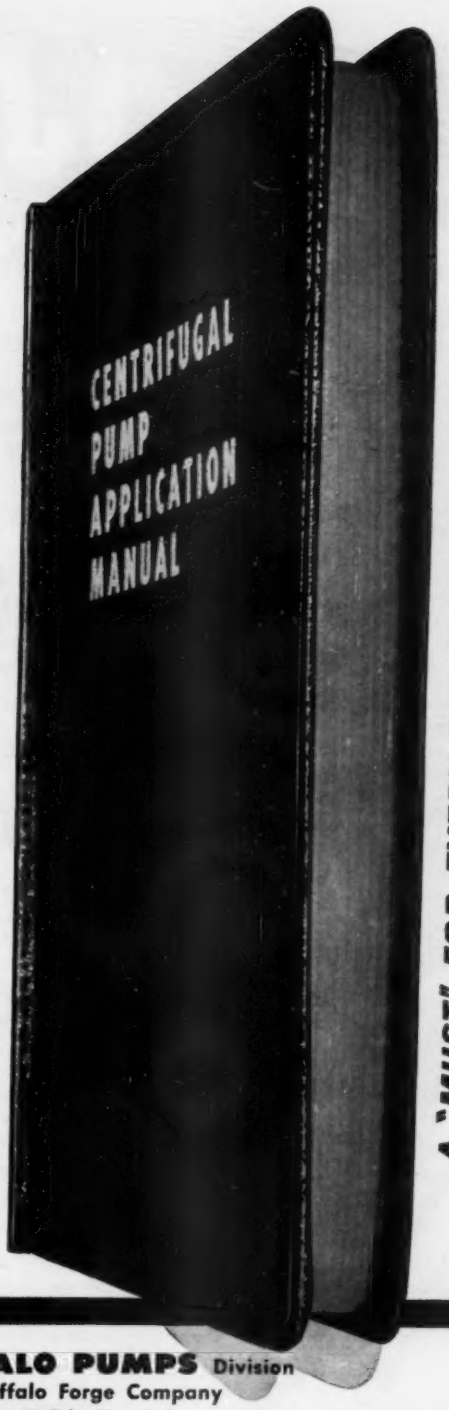

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- Special pumps for moving paper stocks, corrosive and high temperature liquids and slurries.

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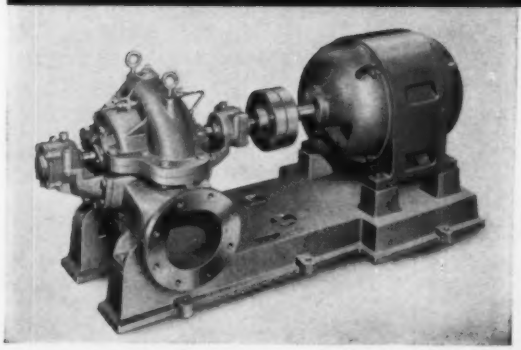

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Buffalo Forge Company
529 Broadway, Buffalo, New York

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Only ROTOJET Tube Cleaners offer the simple, efficient, time-tested Rotocentric design. A single paddle maintains contact with the cylinder wall without depending upon centrifugal force. Motor won't stall at low speeds caused by heavy loads. Positive starting is assured with Rotojet motors driven by air or steam.

Rotojet water-driven Tube Cleaners are comparable in speed and power with air-driven types.

Send for bulletin showing motors, heads, and brushes for straight and curved tubes and pipes from ½" to 12" I.D.

Section of ROTOJET pneumatic motor showing simple design.

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Model C-525 ROTOJET Air-driven Motor with swing-frame head and universal coupling for 2¼" to 3½" I.D. curved tubes.
Model S-530 ROTOJET Air-driven Motor with swing-frame head for 3⅛ to 3-13/16" I.D. straight tubes.
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Model C-434 ROTOJET Junior Air-driven motor, flexible holder, expanding brush.

HYDRAULIC

Model C-322 ROTOJET Water-driven Motor with 3-arm head and universal coupling for 2¼" to 2½" I.D. curved tubes.
Model S-360 ROTOJET Water-driven Motor with combination drill head and universal coupling for 3¼" to 3⅞" I.D. straight tubes.
Model C-321 ROTOJET Water-driven Motor with short 4-arm head and universal coupling for 2½" to 3" I.D. curved tubes.

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assembly instructions. The Imperial Brass Mfg. Co.

159 On Centralized Lubrication — Information on a complete line of centralized systems of lubrication is presented in 24-pp Bulletin 26-T. Advantages and principles of operation are discussed, as well as system components, and illustrations of applications included. The Farval Corp.

160 Belting and Hose — Illustrated and described in 34-pp Catalog 285 are belting and hose products for industry. Lists rubber belting, rubber cover conveyor belts, rough-top rubber belting, food conveyor belting, leather belting, V-belts, belt lacing, air and water hose, rubber-lined hose, welding hose, steam hose, and other products. Benj. B. Nusbaum & Co., Inc.

161 Keep It Clean — How to clean and protect engineering drawings is told in this 6-pp folder. Describes cleaning aids and protective spray, giving ordering information and prices. Keuffel & Esser Co.

162 Aluminum Lighting Fixtures — Bulletin 652 describes design, materials and reliability features of company's aluminum vaportight lighting fixtures. Provides details on labor saving features, technical data, ordering information, prices. The Pyle-National Co.

163 Centrifugal De-Sludgers — Illustrated and described in this product bulletin are centrifuges for recovering solids from suspensions and slurries. Operation details of the de-sludgers are discussed, and dimensions and specifications included. The De Laval Separator Co.

164 Liquid Cleaner — Bulletin P-12591 describes Formula 28, a multipurpose liquid cleaner. Explains how it removes grease, oil, ink, soot, dirt, light carbon and similar deposits from hard surfaces without heat, fumes or fire hazard. Kelite Corp.

165 Flexible Connectors — This technical catalog sheet describes flexible metallic connectors for use on pump installations, hot water systems and steam systems where thermal expansion and vibration are problems. Photos of connectors, construction data and dimensions included. Pennsylvania Flexible Metallic Tubing Co.

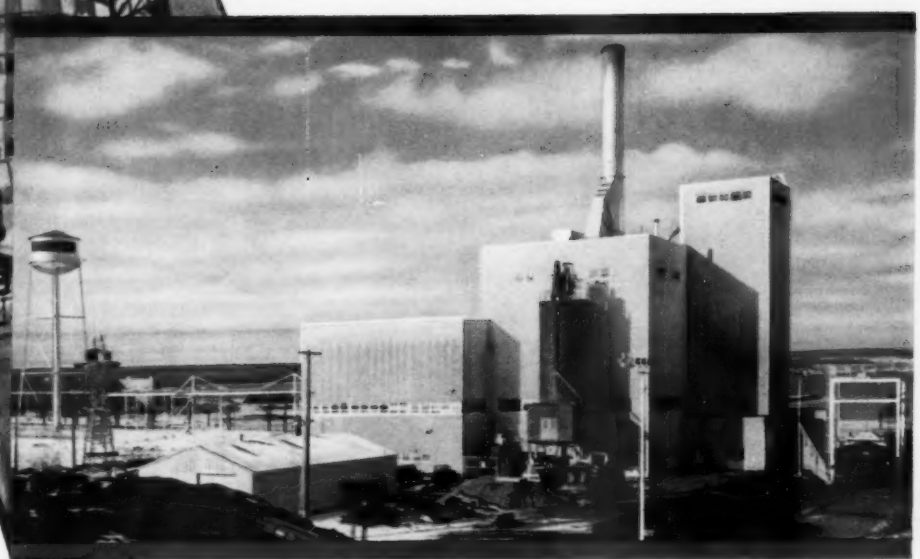
166 Color for Safety — This 6-pp booklet shows a cutaway section of a typical industrial plant with all danger areas painted in appropriate safety colors. Lists recommended colors for every safety application, and gives tips on good housekeeping for industrial plants. Valdura Heavy-Duty Paint Div., American-Marietta Co.

167 Slotted Angle — Twelve-pp Catalog 180 illustrates and describes applications of company's slotted angle for stacking, racking, framing, machine guards, pipe mountings, pallet storage, partitions, bulk storage, and other uses. Construction details and load capacity tables included. Lyon Metal Products, Inc.

168 Protective Coatings — Described in this 16-pp bulletin are a number of protective maintenance coating systems designed to solve a variety of application problems. Index tab indicates where a particular system should be applied, and copy explains features of each system, suggests uses, mentions colors available. The Glidden Co.

Stone & Webster Demonstrates

IMAGINATION IN MICHIGAN



In L'Anse, Michigan, Stone & Webster Engineering Corporation recently designed and constructed the John H. Warden Station for the Upper Peninsula Power Company. Completed within 16 months after ground was broken, the new station not only supplies needed power for a fast growing area, but also fulfills electric power and process steam requirements of the adjacent Celotex Corporation board mill.

Here creative engineering . . . combined with client cooperation . . . provides Celotex with reliable power and steam and eliminates their need for a staff of experienced utility operators. By combining power generation with process uses, substantial fuel savings are realized.

On most engineering projects . . . whatever their scope or purpose . . . the skills and experience of Stone & Webster engineers can effect construction economies and add to a plant's long-term operating efficiency. For complete information on how we might best serve you, call or write our nearest office.

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How Commonwealth Edison Turned a Fly Ash Problem Into Profit

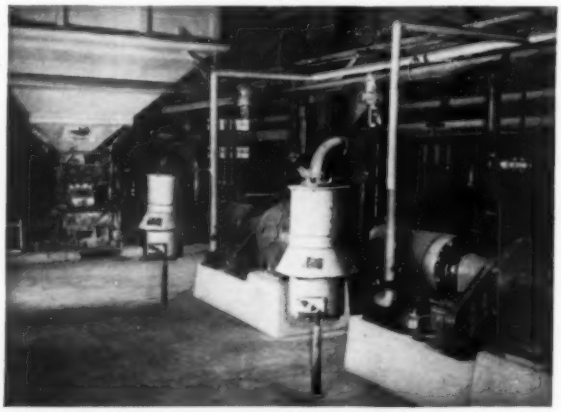
F-H AIRSLIDE FLUIDIZING CONVEYORS ANGLE DOWNWARD from precipitator hoppers, move air-activated ash to 20-ton central surge hoppers under floor. There are few moving parts.

At Commonwealth Edison's State Line Station, about 350 tons of fly ash a day had to be wet down, loaded, and trucked to suitable dumping sites.

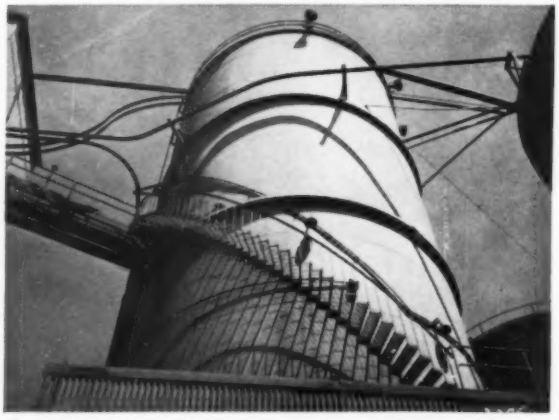
Waste becomes profit. Today, the plant burning a peak load of 5000 tons of coal daily collects dry fly ash automatically in a totally enclosed Fuller-Kinyon system. The ash is conveyed from precipitators to storage bins and silos, where it's sold as a by-product. Manpower: just three men, one at the main control panel and two bagging the ash.

Air and gravity do the work. F-H Airslide® conveyors fluidize dry fly ash by a column of low-pressure air for easy movement by gravity to central surge hoppers. Then, a Fuller-Kinyon pump under each hopper drives the ash by air through a five-inch line to storage. The system is practically maintenance-free. There are few moving parts to foul or wear out.

Large and small plants can get the benefits of Fuller-Kinyon fly ash handling. Capacities range from 100 to 8,000 cubic feet an hour. F-H Airslide and Fuller-Kinyon conveying lines can be curved to avoid beams and other obstacles. Low-pressure air provides power inexpensively and installation costs are significantly less than other types of conveying systems. Write for detailed information in Bulletin FF-49-1.



FULLER-KINYON PUMPS AND COMPRESSORS under surge hoppers propel ash to bins and silos at 20 tons an hour. Fluidized by air, the abrasive, 300°F. ash moves without injuring system.



BULK SILOS receive air-conveyed ash through Fuller-Kinyon pipe-lines. Farthest silo is 1,000 feet from pumps. Over 50% of fly ash is bagged and sold as a by-product.

1335A
G-203 A

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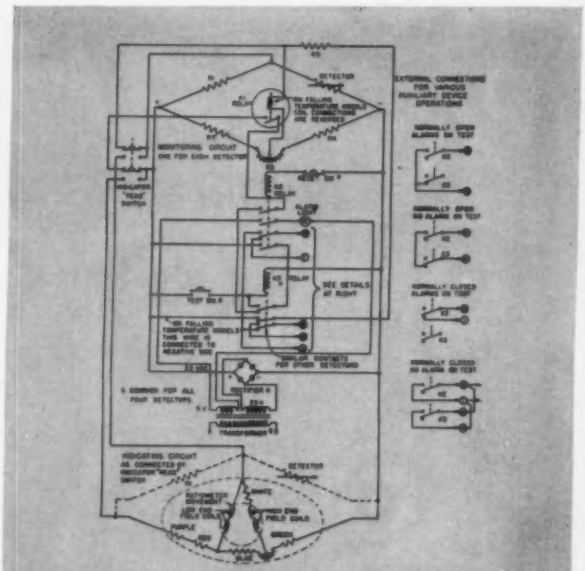
Questions and Answers on the **EDISON OMNIGUARD SYSTEM**

The Most Effective Means of Measuring and Safeguarding Temperatures and Pressures



Q. How does the Omniguard System work?

A. Edison's Omniguard is characteristically simple and unique in its operation. Each Omniguard channel is a conventional D-C Wheatstone bridge circuit in which an Edison temperature or pressure detector forms the variable leg of the bridge. As the temperature or pressure rises and falls, the detector resistance increases or decreases. An Edison relay (K1) across the bridge senses the current flowing through it. When conditions are normal the current flows in the direction to hold the relay contacts open. When a variation occurs, however, current flow reverses and the contacts of this alarm relay close. Relay K1 energizes the coil of auxiliary relay K2 which actuates an alarm light on the panel face to show which detector is "off-normal," actuates an external alarm or annunciator and maintains the alarm indefinitely – until conditions have returned to normal and the normally closed reset switch is opened.

Any temperature or pressure can be read at any time by pressing the indicator read switch for that point.

Q. Is Omniguard dependable?

A. Reliability is built in. Since each measuring channel is an independent, separate circuit, complete system failure is unlikely. Only the most reliable components are used. Edison resistance temperature detectors don't "drift" over years of service. There are *no* scanning mechanisms to wear out . . . *no* delicate components . . . *no* electronic circuits . . . *no* amplifiers . . . *no* periodic maintenance requirements.

Q. Is Omniguard flexible?

A. Completely. A system can monitor as few as 4 or as many as hundreds of variables. Buy only what you need. Since channels are independent of one another, each can be set to alarm at a different temperature or pressure. Alarm settings can be changed easily and quickly.

Omniguard can be used for alarm or shut down of equipment, alarm can be local and remote, is easy to telemeter to remote control station.

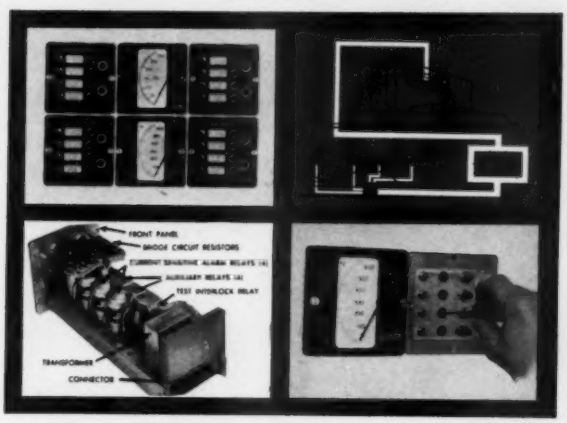
Q. Is Installation economical?

A. Omniguard is the simplest system available. Fewer parts mean lower costs, less maintenance. Plug-in monitors are installed in minutes with no special tools or calibration. Ordinary copper wire connects remote detectors to monitors. Monitor units act as their own annunciators, identify each temperature and pressure, eliminating the need for extra equipment in most installations. Omniguard is a *complete* system with all parts including hardware supplied by Edison.

Q. How accurate are Edison's Resistance Temperature Detectors?

A. In the range from −200°F to +1350°F, no other type of detector is as stable, sensitive, and accurate over years of service. Response times of 0.8 seconds are common – detectors are repeatable to .05% over years of use, resistance being directly proportional to temperature.

Resistance Pressure Detectors are accurate to 1% or better depending on pressure range.



For complete information on the Edison Omniguard System, industry's simplest, most reliable means of continuously monitoring critical temperatures and pressures, write for Bulletin 3036C.

Thomas A. Edison Industries

INSTRUMENT DIVISION

37 LAKESIDE AVENUE, WEST ORANGE, N. J.

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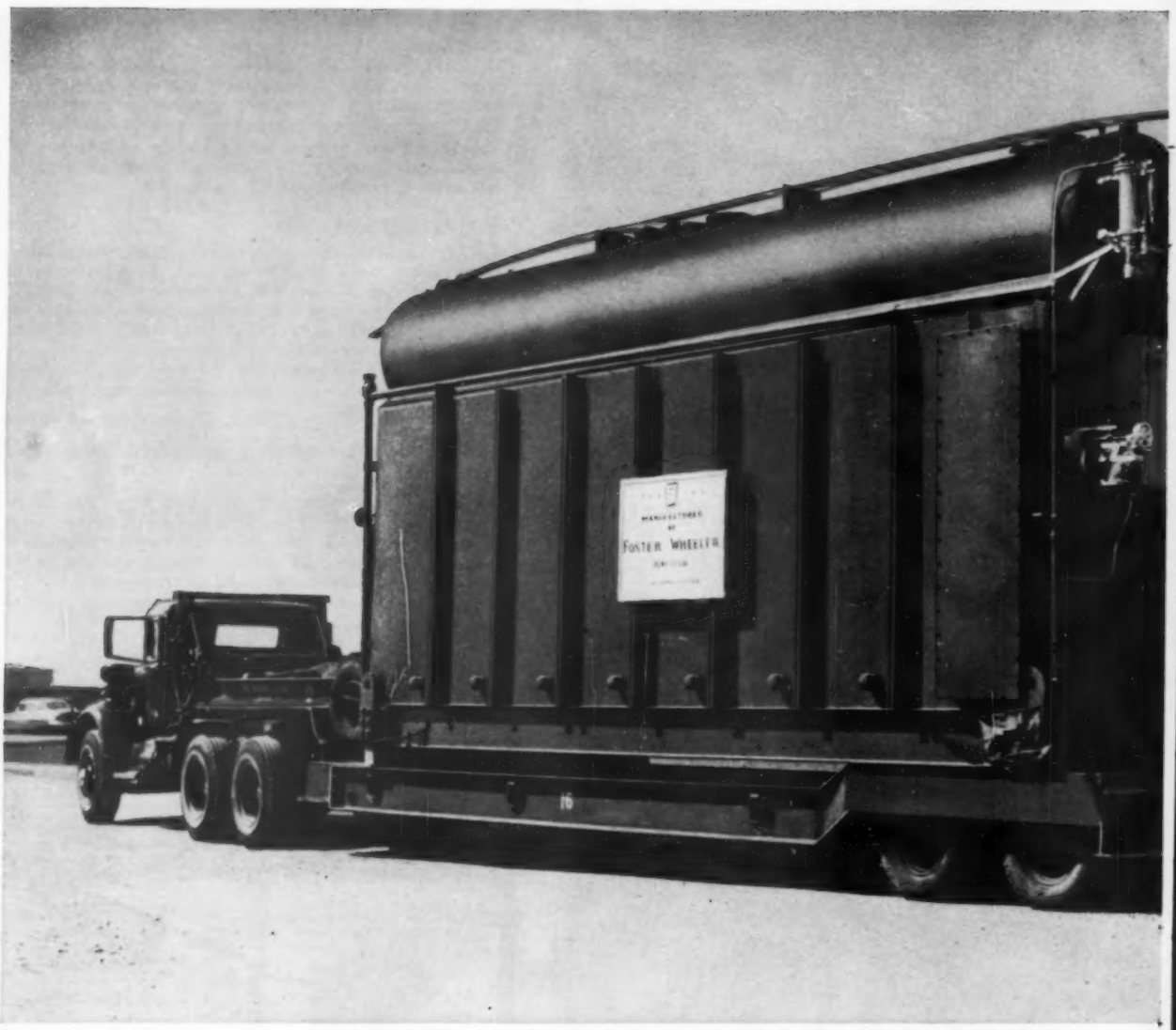
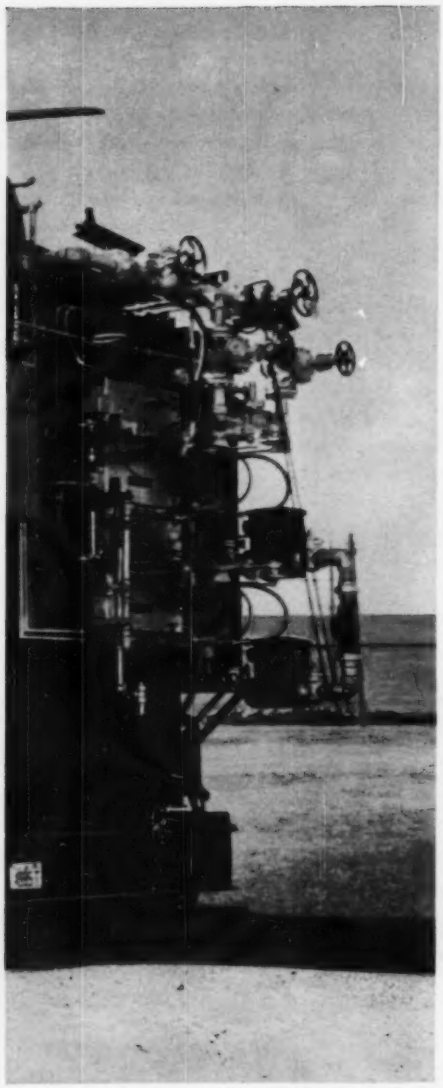


Foster Wheeler Packaged Steam Generator on its way to a refinery, where it is now producing 50,000 lb/hr of high-purity steam for processing and heating purposes.

—PETROLEUM PROCESSING

—CHEMICAL PROCESSING



Foster Wheeler delivers the steam you need and the economy and efficiency you want, in one package

If you need 13,000 lb/hr or more of steam at pressures of 250 psi or above, one of the best ways to begin planning your steam generator installation is by contacting Foster Wheeler right now.

This is Foster Wheeler's record of experience in meeting steam requirements with packaged steam generators.

The first water tube shop-assembled packaged unit was built by Foster Wheeler in 1940, to solve an important defense problem. Today, standard Foster Wheeler Packaged Steam Generators, firing fuel oil and gas separately or in combination, are serving refineries, process and manufacturing plants, hotels, dairies . . . virtually every type of business and industry throughout the world.

Most recent Foster Wheeler development in packaged steam generators is a stoker fired model, the first available to industrial users of steam.

In short, the *heat engineering* experience that goes into Foster Wheeler Packaged Steam Generators is unique in the power industry. And the result is a product engineered for dependable, economical and efficient production of high-purity steam . . . and delivered as a package which keeps installation costs to a minimum.

Make planning your steam generator installation easier by getting full information on Foster Wheeler Packaged Steam Generators *before* you start writing your specifications. Write Foster Wheeler Corporation, 666 Fifth Ave., New York 17, for Bulletin PG-58-2. Or better still, contact Foster Wheeler directly and discuss your steam requirements personally with one of Foster Wheeler's *heat engineering* specialists.

Heat Engineered products, plants and processes . . . for the world's power, petroleum and process industries.

—SPECIALIZED INSTALLATIONS

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AT ASHLAND, KY. WORKS OF ARMCO STEEL CORPORATION

"Increased boiler capacity can often be obtained by modernizing boiler cleaning equipment. Another benefit of such modernization is more efficient utilization of the fuel . . . getting more heat into the steam for useful work and wasting less heat up the stack.

For example, at the Ashland, Kentucky Works of the ARMCO Steel Corporation there are four boilers that were unable to supply the growing steam requirements of the plant. The high exit gas temperatures suggested that a study be made to determine whether the cleaning could be improved to provide additional capacity. This study indicated that more steam from the same fuel could be expected if high pressure long retractable blowers were used for cleaning instead of the rotary blowers with which the boilers were originally equipped.

The expected results seemed sufficiently promising and it was decided to modernize the cleaning equipment of one boiler. The seven rotary blowers were replaced with four Diamond Long Retracting Blowers, one of which is shown below. This modernization proved to be justified as the boiler's maximum steam output was increased 11% and the exit gas temperature was reduced approximately 100° F.

A "Boiler Cleaning Modernization Program" is well worth careful consideration because it can mean substantial savings in so many ways. In addition to increased capacity and more efficient fuel utilization, there is reduced maintenance . . . also reduced operating costs when motorized units and automatic operation are installed. Even though your boiler cleaning was the best at the time it was installed, improvements since then will probably pay off. For many years Diamond has been doing continuous research to improve boiler cleaning and boiler cleaning equipment.

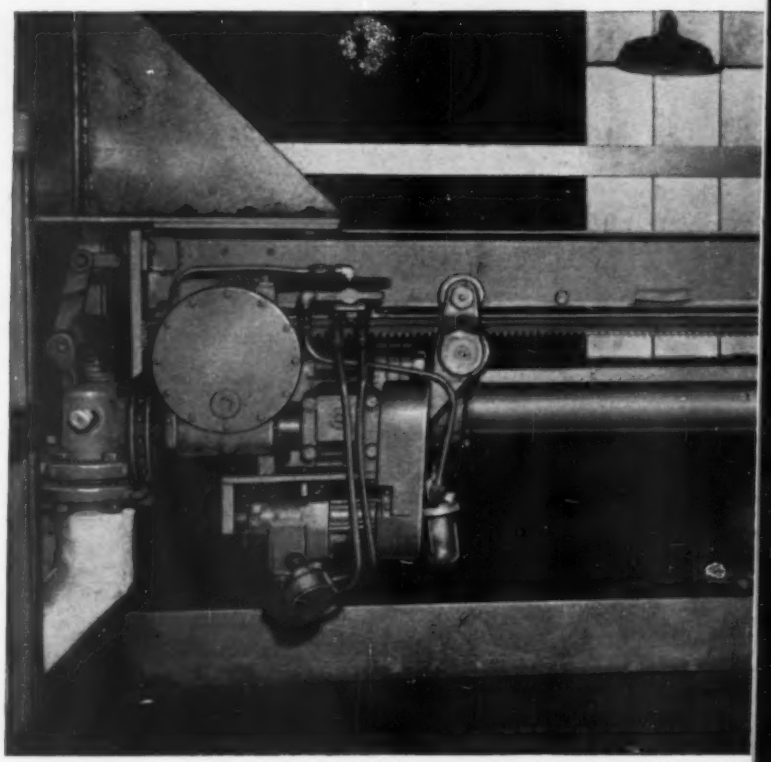
Ask the nearest Diamond office (or write directly to Lancaster) to make a study of your boiler cleaning . . . the possible savings may surprise you."

DIAMOND POWER SPECIALTY CORPORATION

LANCASTER, OHIO

DIAMOND SPECIALTY LIMITED • WINDSOR, ONTARIO

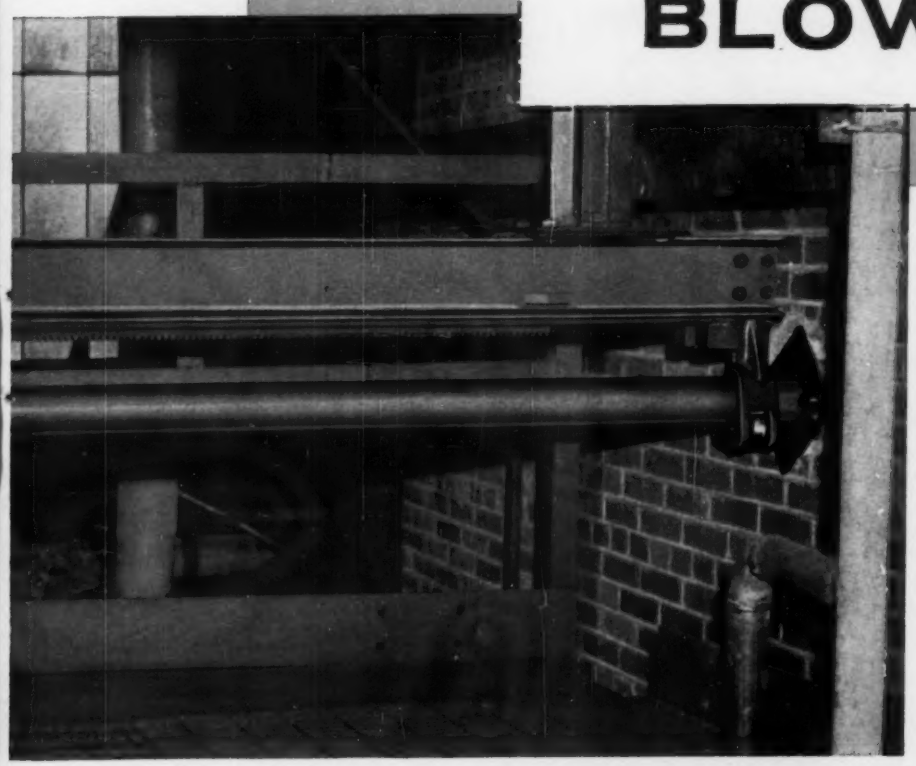
The Mark of
BETTER BOILER CLEANING
AT LOWER COST



11% More Steam 100° F Lower Exit Gas Temperature

RESULT FROM BOILER CLEANING MODERNIZATION PROGRAM

Using DIAMOND LONG RETRACTING BLOWERS



One of the four Diamond Long Retracting Blowers used to modernize the cleaning of the first boiler at the Ashland Works of ARMCO Steel Corporation. The results were so satisfactory that the three other boilers in this plant are now also being modernized.

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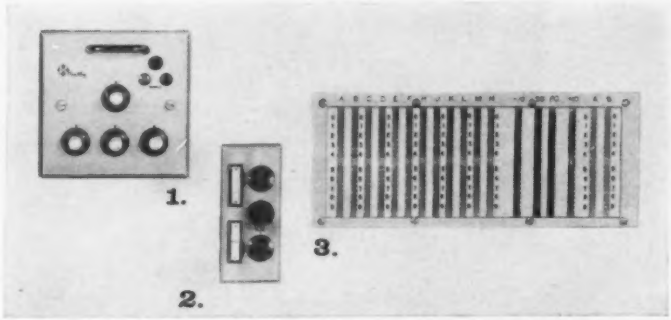
Hagan PowrMag Analog Computer Control

simple as



PowrMag systems embody the highest degree of flexibility. Simple, efficient electrical design utilizing long-lived and trouble-free solid state components, and rugged mechanical construction suit the system for a variety of industrial process control applications.

1. *Magnetic Control Unit*

This magnetic amplifier, operating on 1-9v DC, may be used individually, as a single 2 or 3 mode controller, or as one element in a large system. Each control unit may be removed from the front of the panel for easy interchangeability. The basic unit is easily converted to other modes by the addition of interchangeable, plug-in circuits for *all* common control operations. Inventory is reduced to the one basic unit. Unaffected by shock or vibration, PowrMag has no moisture, dirt, leakage or freezeup problems—3.5 watts of unregulated 110v, 60 cycle AC. Size—5¼" x 5¼".

2. *Remote Control Station*

These stations provide for remotely established set points and required manual control operations. Full station may contain two single or ganged potentiometers, one switch and two meters. Size—2¼" x 5¼". Half stations available with set point, bias or ratio dial and output signal indicator. Size—2¼" x 3⅛". Each station uses 12-wire, color-coded electric cable with MS-type connector. Front mounting and removal make it ideal for the compact console installations required for centralized control.

3. *Patchboard*

Interconnecting the system in any desired manner, via color-coded electrical cable, the patchboard requires no solder connections or terminal boards—all connections are made by special taper pins. Each connection is identified by an alphanumeric combination. Numbers, run vertically, identify the components in the system, such as magnetic amplifiers, controllers, transducers, etc. Letters, run horizontally, identify the connectors leading into the patchboard. DC control power bus is in the center section—no AC voltages are used in the patchboard.

Easy front access permits simple changing of operations. Additional loops or components are readily added to the system.

A letter or phone call will bring you complete information on the PowrMag system. **Ask for Bulletin MSP-163.**

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CHEMICALS & CONTROLS, INC.
HAGAN CENTER, PITTSBURGH 30, PENNSYLVANIA

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You readily see there is an improved whiteness—Super Powerhouse dries *super* white. It withstands rain, sleet and snow after initial set—no redoing jobs because the weatherman erred. It has outstanding coverage, insulates and finishes in one coat yet performs better than many insulating cements.

New advantages such as these make it imperative to check your insulation specifications before rewriting them for a new project. Baldwin-Ehret-Hill offers you the complete line—a selection of over thirty different specialized insulation products for service from sub-zero to 1900 F. Each is designed to give you greater efficiency, easier application and lower installed cost. To bring your specifications up to date, write for our new 1960 catalog or see it in your Sweet's file.

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THE COMPLETE LINE OF INSULATIONS for use SUB-ZERO TO 1900 F.

CONTRACT APPLICATION SERVICE FROM COAST TO COAST

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AI's extensive field laboratory is located in California's Santa Susana Mountains. *Woodcut by Edward Kysar.*

How can A.I. facilities help you plan a Nuclear Program?

In the picturesque Santa Susana mountains near Los Angeles, Atomics International has built an extensive field laboratory for research, engineering and testing in the nuclear sciences. Here, and at a headquarters complex in the valley below, men who pioneered the creative uses of atomic energy are applying their experience to develop advanced nuclear reactors and associated equipment.

Fourteen years of experience in developing various types of reactors for the Atomic Energy Commission and other organizations have given the men of Atomics International a collective background unparalleled in the industry. The facilities at their disposal are among the most sophisticated and extensive in the world.

Results of AI's work have been demonstrated in projects for the AEC which include the Organic Moderated Reactor Experiment at the National Reactor Testing Station in Idaho and the Sodium Reactor Experiment at the company's field laboratory. Additionally, AI built and is operating SNAP II, a 220 pound prototype reactor to produce three kilowatts of electricity for space vehicles.

Atomics International is also building large power reactors for electric utilities in Ohio and Nebraska under AEC programs. Studies are underway for other power reactors in the United States and Europe. Research reactors have been built by AI for Denmark, Germany, Italy, Japan, Puerto Rico and several sites in the United States.

For details contact: ATOMICS INTERNATIONAL, Canoga Park, California, U.S.A. Cable address: ATOMICS.

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A DIVISION OF NORTH AMERICAN AVIATION, INC.
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ATOMICS

A section of POWER ENGINEERING covering current and forthcoming developments in the field of Nuclear Power throughout the world

ANDREW W. KRAMER
Editor

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The CERN Proton-Synchrotron constitutes the most perfect example of scientific and technical collaboration ever achieved among the countries of Europe. Yet, as was pointed out at the dedication ceremonies, its cost, some 120 million Swiss francs, represents the cost of a few cigarettes per capita of the 460 million inhabitants of Europe.

How to Calculate Nuclear Fuel Costs
By H. J. Rubinstein 48
Here is a very practical article for engineers on how to calculate nuclear fuel costs. This is not so simple a process as in the case of conventional fuel, but by taking into account each of the component parts involved in the use of nuclear fuel, costs can be calculated with considerable accuracy.

Sodium—Chemical Properties and Methods of Handling
By Paul C. Ziemke 51
Because of its excellent heat-transfer properties and its good nuclear characteristics, sodium has become a valuable material as a coolant in nuclear reactors. It is, however, a tricky metal to handle, and in this article Mr. Ziemke tells how they handle it at Oak Ridge.

The CERN Proton-Synchrotron—World's Largest "Atom-Smasher" 53
A brief description of the 25 Gev accelerator at CERN, near Geneva, Switzerland. The construction of this magnificent machine represents a high point in the continued advance of European nuclear technology.

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SCIENCE—PURE AND UNADULTERATED

FEBRUARY 5, 1960 marked an occasion of great significance in the world of science. On that day, the great new 25-Gev proton-synchrotron of CERN near Geneva, Switzerland, was officially dedicated in the presence of an illustrious group of scientists from countries all over the world. Never in history has the inauguration of a machine built for scientific research caused such a stir of interest on the part of government authorities and of public interest, and rightly so, for the construction of this almost fabulous machine is not only a technical achievement of high scientific significance but it is also a symbol of the common enterprise of people from many nations to give all mankind a new understanding of the forces that shape our physical environment.

The CERN proton-synchrotron is the largest machine of its kind in the world. In terms of energy it is two-and-one-half times greater than the 10-Gev proton-accelerator at Dubna, near Moscow, and at least 8 times more powerful than the Cosmotron at Brookhaven National Laboratory, which was inaugurated in December, 1952. As explained in the article on page 53, despite the tremendous physical size of this machine —measured in hundreds of meters—its construction called for close tolerances such as are generally found only in the finest precision instruments.

The importance of the ceremonies on February 5 cannot be accounted for only by the prodigious technical achievement which the new accelerator represents. Far beyond its scientific importance, it testifies to the political significance, in the most exalted sense, of the fulfilment of the task which the Member Countries of the CERN organization had given the Director-General and his staff six years ago. It is a tribute to the success of the greatest coöperative venture for the furtherance of human knowledge to reach its goal on an international scale. For it should be stressed that CERN is a multinational organization which works exclusively in the field of pure and fundamental research. CERN is not concerned with applications of nuclear energy, whether pacific or military. CERN is dedicated to the satisfaction and intellectual curiosity in the highest sense of the word—the ultimate secret of matter. A center like CERN, whose existence and work depends on international effort, and where even a suggestion of secrecy is banished, proclaims profound faith in the unity of our culture and in the universal value of its message. The men from different nations who meet at CERN to work together on a completely pacific and disinterested task are united by a common desire for knowledge and subject to the rigid rules of intellectual honesty. Some of our national and private research institutions on our side of the Atlantic, hemmed in as they are on all sides by guard-posts and so-called security restrictions, might find a lesson of great and lasting value in the completely free and intellectually healthful atmosphere at CERN.

Andrew W. Kramer

How to Calculate Nuclear Fuel Costs

The calculation of fuel costs for a nuclear power plant is not as simple as it is for a conventional steam plant. Not only is the cost of the consumed fuel itself included, but the auxiliary costs of preparing the fuel before burning and the processing of the spent fuel after discharge from the reactor are included as well. The following article discusses the various component parts of the nuclear fuel cost and tells how to calculate costs by means of an example

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IN A conventional plant, the fuel cost in mills per kwh is simply the net station heat rate in Btu per kwh times the cost of fuel in cents per million Btu times 10, or: FC = HR × FP × 10 ÷ cents.

The auxiliary operations of preparing the conventional fuel for burning and discharging the burned products are small in cost and are generally included in the cost analysis by a slight increase in the net station heat rate.

In a nuclear plant using solid fuel elements, the fuel burnup represents only about half the total fuel cost, and the rest of the cost is due to other components. These are:

1. Fuel element fabrication. The uranium fuel must be fabricated and contained in a form which can be accepted within a nuclear reactor. The fuel is in the form of uranium hexafluoride (UF_6) when purchased by the AEC. The UF_6 must be converted to UO_2 powder or to uranium metal, depending on the type of fuel element used. The fabricated fuel elements may take the shape of either uranium metal plates clad with zirconium or that of zirconium or stainless tubes about one-half inch in diameter, which are filled with small pills of uranium oxide. The fabrication process is a costly one because close tolerances are held, and the cost of making special reactor grade materials like zirconium and UO_2 are high. Each fuel element is carefully inspected and tested to assure that its integrity is good and that it will not become a "leaker" when in service.

2. After the fuel is exposed to its practical limit in the reactor, it must be taken out and transported to a chemical processing plant which will recover and separate the valuable materials which are still left in the fuel. The fuel is highly radioactive, and the handling must be done with shielded casks and with great care. Under these conditions, the cost of shipping spent fuel to the reprocessing plant becomes appreciable and must be added to the fuel cost.

3. After the fuel is received in the chemical processing plant, the fuel elements must be reduced by remote operation to a liquid-nitrate or other form which can be handled chemically. The fission products are separated from the uranium and plutonium. The resulting uranium nitrate must be converted to uranium hexafluoride (UF_6) and returned to the enrichment plant at Oak Ridge. The separated plutonium nitrate is converted to the metal and sold to the AEC at the current plutonium buy-back price. The cost of reprocessing itself is guaranteed by the government at a cost of $15,300 for each day of operation. This cost is based upon a through-put capability of one ton per day of spent fuel.

4. The total amount of fuel used by a utility for operating a reactor, including that fuel which is in various parts of the fuel cycle, is leased by the AEC for a "Use Charge" of four per cent of the value of the fuel. This eliminates the necessity to buy the fuel outright which would require very large outlays of capital. A 200-Mwe plant may have 15 to 20 million dollars worth of fuel borrowed from the AEC.

To summarize, the components that make up the total fuel costs are:

1. Fuel consumed or burnup.
2. Fuel element fabrication.
3. Shipment of exposed fuel.
4. Reprocessing of exposed fuel and conversion to UF_6 and Pu metal.
5. Credit received from the AEC for the plutonium received.
6. The rental or use charge on total fuel inventory.

Figure 1 shows schematically the flow of fuel in the fuel cycle.

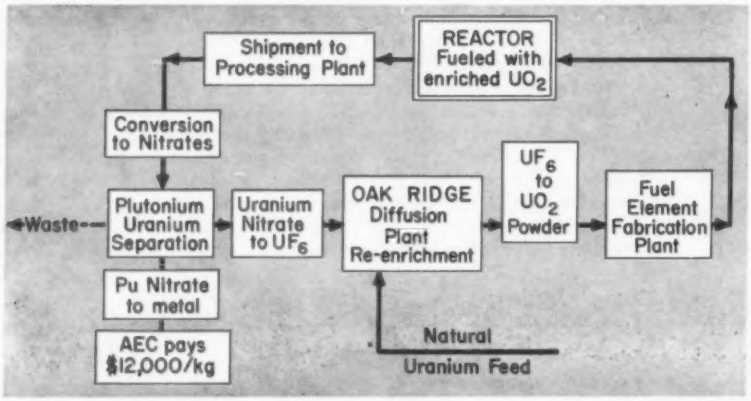

Fig. 1. Fuel cycle flow diagram for a UO_2 fueled reactor

Burnup

The effectiveness of the "burning" of nuclear fuel is called burnup. It is expressed in terms of heat received per unit of fuel weight charged into the reactors. The most common units used are megawatt days per tonne or Mwd per tonne. Since metric weights are generally used in pricing various operations in the fuel cycle, the tonne refers to a metric tonne of 1000 kg, which is equivalent to 2200 pounds. For UO_2 fuel, average burnups in the

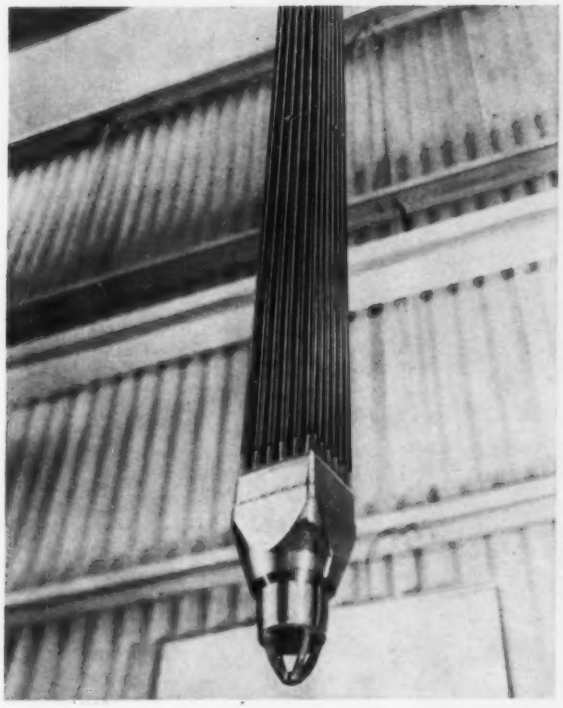

Fig. 2. One of the fuel elements for Dresden Station of Commonwealth Edison Co. This is typical of the tubular UO_2 pellet-filled fuel element array. Bottom orifice controls coolant flow, and spider is used for positioning element into place

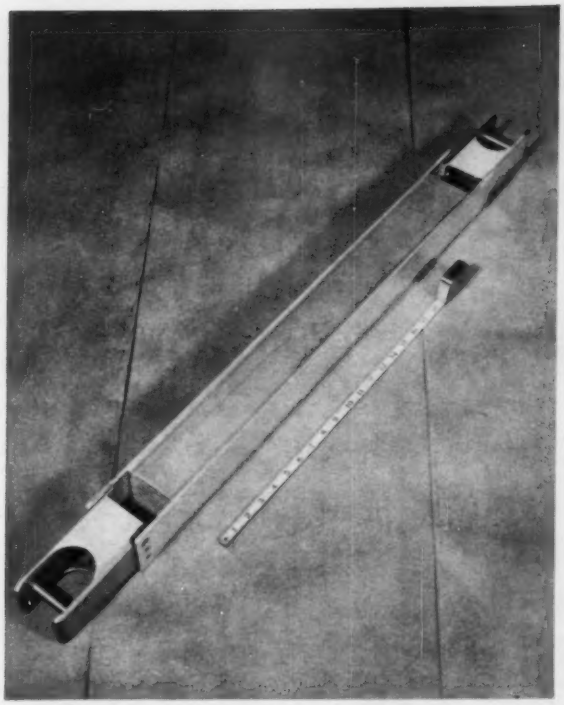

Fig. 3. Here is a photograph of a typical plate-type fuel element. This particular element is an aluminum-clad unit used in a research reactor. The construction is similar to the flat plate design used in power reactors

TABLE A—Cost of Uranium—235*

Weight Fraction of Contained U^{235}	Fuel Value $/kg	Fuel Value $/gm of Contained U^{235}
.72 (Natural U)	$ 40.50	$ 5.62
.80	50.00	6.25
.90	62.75	6.97
1.00	75.75	7.58
1.50	145.50	9.70
2.00	220.00	11.00
3.00	375.50	12.52
4.00	535.50	13.39
5.00	696.25	13.96
10.00	1,529.00	15.29
90.00	15,361.00	17.07

*Based upon AEC prices published in TID-4559 (Rev) March 1957

range of 10,000 to 20,000 Mwd per tonne are to be expected from our first cores, and even higher burnups may be obtained in later and more advanced cores.

The actual cost of the fuel used up is the difference in value of a kg of fuel before charging and after removal from the reactor for reprocessing. The AEC has fixed prices on this as shown in Table A. The value of a kg depends upon its "enrichment" or percentage of U^{235} contained in the U^{238} base material.

It is seen that the value per gram of contained nuclear fuel increases rapidly with U^{235} content. For this reason, most power reactors today use enrichments of about two or three per cent.

Example: Let us assume that we have a 200-Mwe water-cooled (either boiling or pressurized type) reactor which uses fuel enriched to 2.0 per cent. The fuel gives 12,000 Mwd per tonne of heat, and when it is removed from the core, it has a residual enrichment of 1.0 per cent and the spent core has 0.5 per cent plutonium which was made from U^{238} under neutron irradiation during the core lifetime. The calculation of burnup cost would be as follows:

	$/kg
Initial fuel value 2.0% U^{235} (Table A)	$220.00
Final fuel value 1.0% U^{235} (Table A)	75.75
Cost of consumed fuel	$144.25
Credit for plutonium @ $12,000/kg	
$/kg = 0.005 $\frac{\text{kg Pu}}{\text{kg Fuel}}$ × $12,000 =	$ 60.00
Net fuel cost, $/kg	$ 84.25

The AEC buy-back plutonium price is assumed at $12,000 per kg, which is considered the useful fuel value. The present price the AEC pays is much more than $12,000 per kg of Pu (about $30,000 per kg). This inflated and artificial pricing will last according to law until June 30, 1963. After this time, it is expected that the AEC will pay only the useful fuel value for the plutonium.

Fuel Element Fabrication

The cost of the fabrication of fuel elements is entirely a private matter between the core manufacturer and the utility. The actual cost is dependent upon the complexity, tolerances, inspection, and cost of the fuel element materials. Published figures on core costs indicate that the industry today is aiming at costs in the range of $100 to $140 per kg of U, depending upon whether the cladding is stainless steel or zirconium — the lower figure being for the stainless.

For our example, we will assume that the fuel is clad with zirconium and that the fabrication cost is $140 per kg.

Reprocessing Costs

The AEC has established charges of $15,300 for each day of reprocessing plant operation. The plant is

Fig. 4. These are the fuel element storage racks at Dresden Station. Spare elements are stored here before insertion into the reactor. Note careful handling and monitoring required

assumed to process one metric ton per day. However, when a new batch of fuel is processed, there is time lost by the processing plant for adjusting to the newly arrived fuel. This adjustment period or "turn-around time" is generally considered to be about 8 days. The turn-around time adds about 25 per cent to the reprocessing cost for a 200-Mwe reactor which operates with a 70 per cent capacity factor. The reprocessing cost is then:

AEC Reprocessing Cost = 15.3 \$/kg × 1.25 = 19.1 \$/kg

The AEC charge for conversion of uranium nitrate to UF_6 is currently \$5.60 per kg.

The AEC cost of converting plutonium nitrate to metal is now \$1.50 per gram of plutonium. The cost per kg of fuel for a reactor that produces 0.5 per cent Pu would be as follows:

$$\text{Converting to Pu Metal} = \$1.50/\text{gm Pu} \times \frac{0.005 \text{ kg Pu}}{\text{kg Fuel}} \times \frac{1000 \text{ gm}}{\text{kg}} = \$7.50 \text{ kg fuel.}$$

The total reprocessing cost becomes: \$/kg

Chemical reprocessing	\$19.10
U Nitrate to UF_6	5.60
Pu Nitrate to Metal	7.50
Total Reprocessing	\$32.20 per kg

Shipping Cost

The spent fuel must be shipped in heavy shielded casks to the AEC reprocessing plant. For the 134-Mwe Yankee reactor at Rowe, Massachusetts, the following costs are estimated:

	\$/kg
Freight from New England to Hanford, Washington	\$ 2.80
Freight from Hanford to New England (return of empty casks)	1.40
Cask rental	1.30
Courier charge	0.50
Insurance	4.00
Total	\$10.00

The shipping casks in this case weigh 60,000 pounds each, but only 2000 pounds of spent fuel can be shipped in each cask. It is expected that four casks of this type will be rented and used for a period of only three months each year.

According to law, all special nuclear material within the United States is the property of the U.S. Government. This means that one may not buy enriched nuclear fuel outright. The AEC lends the fuel to the user at a charge of 4 per cent per annum of the average value of all the fuel in the cycle. For our example we will assume that the average value of the fuel is the average of the fresh fuel and the spent fuel, or:

$$\text{Average Value} = \frac{220.00 + 75.75}{2} =$$

\$147.88 per kg.

We must assume, however, that at all times there is more than one core load of fuel borrowed because of the time required to fabricate and reprocess fuel elements. A total fuel inventory of 1.5 cores will be considered necessary. At 4 per cent per year, the charge for borrowing fuel from the AEC would be:

\$/yr per kg charged into the reactor = 147.88 × 0.04 × 1.5 cores = \$8.87.

We will assume that the entire fuel cycle of fabrication, irradiation, and reprocessing takes four years, which is composed as follows:

	Years
Fabrication	0.5
Residence in Reactor	3.0
Reprocessing and shipping	0.5
Total time	4.0

The cost per kg for fuel use is

Use charge = 8.87 × 4 yr = \$35.5 per kg.

Total Costs

We may now total all the fuel costs on a kg basis:

	\$/kg
Net fuel consumed (including Pu credit)	\$ 84.25
Fuel element fabrication (including conversion UF_6 to UO_2 powder)	140.00
Total reprocessing (including nitrate conversions)	32.20
Shipping cost	10.00
Use charge	35.50
Total cost per kg charged to the reactor	\$301.95

To convert the total cost per kg of fuel to mills per kwh, additional information about the reactor operation must be known. These are the average fuel burnup and the net plant efficiency. For this example, assume:

Average burnup..... 12,000 Mwd per tonne
Net plant efficiency... 29 per cent.
The fuel cost per kwh will be:

$$\text{Fuel Cost} = \frac{\$301.95/\text{kg} \times 1000 \text{ kg/t} \times 1000 \text{ mills/\$}}{12{,}000 \text{ Mwd/t} \times 0.29 \text{ (eff)} \times 24{,}000 \text{ kwh/Mwd}} = \frac{301.95 \text{ \$/kg}}{12{,}000 \text{ Mwd/t} \times 0.29 \text{ (eff)}} \times 41.6$$

= 3.61 mills/kwh.

The fuel cost of 3.61 mills per kwh is equivalent to 29.8 ¢/million Btu at 29 per cent efficiency (11,800 BTU/kwh).

Conclusion

An inspection of the component parts of the fuel costs indicates that the lion's share is taken up by fabrication costs. Many people in the nuclear business are placing their hopes on the possibilities of reducing

fabrication costs when fuel elements become more standardized and manufacturing techniques are improved. Some believe that fabrication costs may be cut in half in the future. If this eventuality is realized, the fuel cost would drop one mill per kwh and the total would be 2.61 mills per kwh for the example. It is also seen that the fuel cost is directly related to the average burnup. If burnup of 20,000 Mwd per tonne will be realized, the fuel cost would be almost cut in half again. It is, therefore, in the foreseeable future that fuel costs may emerge in the 2 mills per kwh range. This is, of course, based upon higher burnups than are presently expected and also much lower fabrication costs.

Capital Costs

Although this discussion is concerned primarily with fuel costs, I would like to point out a capital cost component that is often neglected in nuclear economics.

This is the working capital required to support the fuel cycle. In the example covered here, an initial outlay of:

$$\text{Fuel Fabrication Cost} = \frac{\$140}{\text{kg}} \times \frac{0.08\ \text{kg}}{\text{kw (therm)}} \times \frac{200{,}000\ \text{kw}}{0.29\ \text{(eff)}} \times 1.5\ \text{cores} = \$11{,}600{,}000.$$

This calculation assumes a specific uranium content of 0.08 kg per kw which is representative for a boiling-water reactor. Note that the factor 1.5 is used because there is more than one core in the cycle at all times. The fabrication costs must be treated in a similar manner to plant capital costs, although no depreciation should be included because this is taken care of in the fabrication portion of the fuel cost calculation. For a privately-owned utility with fixed (non-depreciating) charges at 12 per cent and a capacity factor of 70 per cent, the cost of fuel working capital in terms of mills per kwh would be:

$$\text{Fuel Working Capital Cost} = \frac{\$11.6 \times 10^6}{200{,}000\ \text{kw}} \times \frac{0.12}{8760\ \text{hr/yr} \times 7\ \text{(C.F.)}} \times \frac{1000\ \text{mills}}{\$} = 1.13\ \text{mills/kwh}$$

Plant capital costs and operating and maintenance costs would be added to the above to obtain the total capital charges. In order to make this example complete, we will assume that the plant capital cost is $280 per kwe* and the operation and maintenance is 1.0 mill per kwh. The total fixed charges, including depreciation, are assumed at 14 per cent.

*Published cost of the Dresden Nuclear Station of Commonwealth Edison Company

$$\text{Capital Charge} = \frac{\$280}{\text{kw}} \times \frac{0.14}{8760 \times 0.7} \times \frac{1000\ \text{mills}}{\$} = 6.38\ \text{mills/kwh}$$

The total unit power cost of this hypothetical nuclear power plant is:

	Mills/kwh
Plant	6.38
Working fuel capital	1.13
Fuel cost	3.61
Operation and maintenance (including insurance)	1.00
Total	12.12

For a municipally-owned utility, this figure would be decreased by about 3 mills if the depreciating fixed charges are reduced to 8 per cent and the non-depreciating fixed charges reduced to 6 per cent.

Although the figure of 12 mills/kwh does not look very competitive today, it must be remembered that the areas of fuel costs and plant capital cost are subject to considerable reductions. This is where the hope lies in achieving economic nuclear power. THE END

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Sodium—Chemical Properties And Methods of Handling

By PAUL C. ZIEMKE

Sodium's excellent properties as a high-temperature heat-transfer medium has made it very useful as a coolant in nuclear reactors. This metal, however, has certain unusual chemical properties which present hazards to personnel and structural materials unless it is handled properly. The following description of the methods of handling this metal at Oak Ridge National Laboratory should therefore be of interest to those who may be involved in its use

SODIUM HAS COME into considerable prominence in recent years because of its usefulness as a heat transfer medium in nuclear reactors. Although the chemical and physical properties of sodium have been known for many years, until now there has been no occasion to handle this metal in large quantities; consequently its use in the nuclear industry has made necessary the development of safe handling techniques, some of which are described in this article. These refer specifically to the methods of handling used at the Oak Ridge National Laboratory.

Sodium, Na, is a relatively soft, silvery-white metal which melts at 206 F. Molten sodium is silvery-white in appearance, and its outstanding characteristic is its reactivity with most gases and liquids, the noble gases excluded, however. In any consideration of the use of sodium as a heat transfer medium or as a reagent, particular attention must be given to the possible reaction of sodium with materials most likely to be encountered in process systems or in handling. Solid sodium tarnishes almost immediately when exposed to air due to the formation of an oxide film. Molten sodium burns readily in the normal atmosphere, forming dense fumes of sodium monoxide. With pure oxygen, molten sodium burns with a yellow flame, forming a mixture of sodium monoxide and sodium peroxide. Molten sodium also combines directly and vigorously with hot hydrogen to form the hydride — NaH, a white to grayish powder which is very hygroscopic. NaH is relatively stable; the decomposition of NaH by heat has been studied to show that hydrogen, either as hydride or hydroxide, can be eliminated from the sodium by heating with removal of hydrogen as it is evolved.

The reaction of sodium with water is energetic and possibly explosively rapid, if the contact interfaces are large. The action of sodium in contact with the atmosphere is of great importance in that the end product after heating is NA_2O, which results in a considerably increased attack on metal containers. Alcohols react similarly with sodium but less rapidly, and the greater the number of carbon atoms in the alcohol, the less rapid the reaction. Laboratory equipment containing sodium can be cleaned by the slow and careful addition of alcohol or a mixture of kerosene and alcohol.

At high temperatures, carbon dioxide is reduced to carbon monoxide and the formation of sodium carbonyl by the reaction of carbon monoxide with sodium dissolved in liquid ammonia. The formation of the carbonyl

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directly from sodium and carbon monoxide is still unreported.

Liquid ammonia will dissolve appreciable quantities of sodium, and it is reported that it is soluble in certain amines. Sodium and halogenated hydrocarbons react explosively. Therefore, they should be prevented from coming in contact. Sodium reacts vigorously with halogens, acidic oxides and mercury; alloys with lead, tin, zinc, bismuth and other metals.

Safety Precautions

Residue of sodium may be removed from equipment by reaction with alcohols. The rate of reduction can be controlled by suitable choice of the alcohol, tertiary butyl alcohol giving a slow reaction as compared to methyl or ethyl alcohol. Similarly, the residue can be covered with some material such as benzine or toluene and alcohol slowly added to the hydrocarbon. However, there is a possibility that the hydrocarbon evolved, as well as the alcohol or hydrocarbon vapors, will ignite in contact with air. The vessel containing the residue should be freed of air, then the proper use of a nitrogen flow will prevent ignition.

Burning sodium evolves a heavy smoke which is extremely irritating to the mucous membranes and only somewhat less to the moist skin. Personnel exposed to oxide fumes must be equipped with suitable filter-type respirators for light exposures, and with oxygen or fresh-air-supplied masks, along with proper protective clothing. Again, light concentrations require rubber clothing, while continued heavy concentrations require air-inflated suits. When sodium catches fire in open vessels, quick action is required to reduce the temperature and the contact with air. Dry soda ash is cheap and readily available but is often not properly stored to keep the moisture content low. More dependable results are achieved where the ash is well pulverized and bagged, then stored in electrically heated cabinets. The manufactured product, Mex-L-X, contained in conventional cylinders and dispensed by nitrogen pressure, is an excellent extinguisher, yet has some corrosive effects on metals.

Graphite dust of 25 mesh has been found extremely effective, both from the point of smothering the reaction and its neutral qualities in relation to contact with metals. Its effective application requires the spreading on of even layers, fully shielding the sodium, both reactive and quiescent. Its layered application is required since an excessive weight causes the material to sink through the molten mass to form sodium graphite sponge, which results in a slowing of the reaction but achieves very little extinguishment. Also, the displacement of the sodium causes expansion which spills over the sides of the container.

When carefully applied, the graphite forms a homogeneous mass of slag which effectively seals off the oxygen and thereby accomplishes rapid extinguishment. After cooling, the hard slag is easily removed from the surface of the congealed mass and may then be readily transported for disposal. It has been found advisable to protect the concrete floors of those areas immediately beneath large sodium-circulating rigs with a 4-in. layer of graphite, superimposed with metal grills and toe boards. This arrangement absorbs the sodium resulting from ruptures or other types of leaks that would otherwise spall the concrete and possibly escape beyond the confines of the shielding. Sodium-circulating rigs employing both high temperatures and pressures are required to be shielded by black iron structures having hinged or rolling sections provided to gain access for servicing during "down times." In so far as is possible, valve settings are operated by remote controls extending to the operator's position.

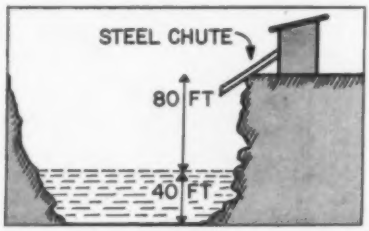

Diagram of quarry used for the disposal of waste sodium at Oak Ridge

Protective Equipment

The choice of work clothing in handling sodium lies between a Dynel coverall having excellent non-fire sustaining qualities, yet not being very resistive to a direct burst of spraying alkali metal, and cotton shirts and trousers. As a first line approach to handling spills, firemen's type fibreglass helmets provided with a wide vision, heavy Plexiglas face shield, and a chrome tanned, horsehide draped hood provide head protection. Body protection is achieved by heavy weight, chrome tanned, horsehide smocks equipped with snaps for ready removal. Horsehide gloves and safety shoes complete the ensemble.

For the critical emergencies, dependence is placed on heavy duty, six-ply clothing fabricated from Vinyon-N, corronized glass cloth, ½-in. felt insulation, 200-mesh nickel steel, corronized glass cloth and orlon. This is made up in a face-shield-equipped hood, smock and boots. To date no occasion has developed to require the use of this equipment, since it is possible to cut off fuel, inert gas pressure, and discharge rig contents to the sump tank.

Key personnel is trained to render immediate first aid for liquid metal burns. All persons exposed to concentrated toxic fumes are sent to the hospital for treatment.

Small equipment containing residues of sodium are cleaned as promptly as possible, since air may enter the equipment, and the resultant reaction of moisture and sodium may readily create an explosive mixture. End openings are sealed with impervious tape to render the configuration air tight.

The work is performed in a stainless steel hood provided with ventilation and counter-balanced sliding doors. Each cleaning operation is determined on its merits; alcohol-kerosene combinations plus dry steam are used as already mentioned; inert atmospheres are used if the situation merits. The larger apparatus is temporarily sealed and transported to the outdoor cleaning station where a semi-circular steel barricade is provided with an ample overhead to fend off spurting reactors. Dry steam is jetted on the contaminated apparatus through flexible controls arranged on the outside of the barricade. Condemned equipment is sealed and dumped in the quarry.

The quarry is approximately one acre in area, has an average depth of 50 feet, with perpendicular rock face of 80 feet. A fire-proof structure surmounts a steel chute projecting beyond the cliff overhang. Loaded trucks back under a steel shed where packaged materials are transferred to the chute. Bulk disposals are given special attention by weighting the 55-gallon drums with 50 lb of small dimension scrap iron poured in through the bung hole. Molten alkali metals, exclusive of NaK, are poured in, and when cooled, are covered with waste crank case oil and the bung plug replaced. At the disposal dock the plug is removed and additional holes punched in the upper end of the drum to permit speedy removal of the oil at the quarry depths. Reactions at maximum depth result in excellent control with no reactive material rising to the surface, almost complete elimination of fumes, and an appreciable reduction in noise.

NaK disposals have been improved by eliminating the work of freezing or submerging in kerosene, with the ear-splitting reactions taking place on the surface of the pond. A cable-supported, ⅜-in. ID copper line is extended to a float at midpoint in the quarry, with the upper terminus anchored near the disposal shed. NaK is transported to the site in conventional stainless steel drums, is pressurized with 20 lb of helium, and jetted out at the water level.

The reaction in air is well controlled, with a minimum of noise and flame, but with copious quantities of fumes developed. The latter condition renders the premises untenable on a day where lack of prevailing wind tends to confine the fumes to the immediate area. Underwater jetting appears to be a solution.

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The CERN Proton-Synchrotron— World's Largest "Atom-Smasher"

THE CERN 25 thousand million electron-volt (25 Gev)* proton-synchrotron near Geneva, Switzerland, was officially inaugurated by Professor Niels Bohr on February 5, 1960. This particle accelerator is the largest in the world.

Completed after six years of joint effort by the 12 founding Member States of CERN (European Organization for Nuclear Research), the proton-synchrotron is a circular accelerator designed to give protons the very high kinetic energies necessary to enable them to strike and penetrate other atomic nuclei. Accelerators can be classed under two main headings, namely linear and circular accelerators. The latter group includes the cyclotrons, betatrons, and synchrotrons. One of the most powerful accelerators, as regards energy of the particles, is the proton-synchrotron — the type installed at CERN.

An aerial view of the CERN nuclear research center is shown in the photograph on this page. The circular earth wall surrounding the proton-synchrotron can be recognized, with the adjoining buildings in the left foreground. Although the CERN installation is remarkable alone on account of its size, the full achievements of the scientists and engineers become apparent only when some of the problems they have solved are taken into consideration. In the CERN accelerator, the protons to be accelerated are produced from atoms of hydrogen gas by an ion source. Then they enter a *Cockcroft-Walton* pre-accelerator where they undergo initial acceleration up to 500,000 electron-volts (500 Kev). After this they are again accelerated in successive steps by a linear accelerator which brings them up to a kinetic energy of 50 million electron-volts (50 Mev), or an injection speed of about one-third that of light.

Thus, the particles reach the end (the hypodermic needle) of the injection system. In six microseconds they are injected through the inflector into the synchrotron proper, the circular part of the machine. The vacuum chamber which serves as their *race-track* is a ring-shaped structure 656 ft in diameter and 2060 feet, or more than one-third of a mile in circumference. Here the protons are accelerated by electric fields through the 16 accelerating cavities located around the ring. In addition, an increasing magnetic field produced by 100 magnet units keeps the beam of particles focused in their orbit within the vacuum chamber. The latter has a 5.6 x 2.8-inch cross section. Pick-up electrodes, by determining the position of the proton beam relative to the side walls of the vacuum chamber, aid in this performance, which is a remarkable one in view of the small cross section and of the fact that in one second, the duration of the acceleration cycle, the protons go round the vacuum chamber almost 480,000 times. Their trajectory, therefore, exceeds three-quarters of the distance between the Earth and the Moon. When the process of acceleration is finished, the velocity of the particles reaches 99.94 per cent of the speed of light, and at this speed, their energy is 25,000 million electron-volts.

A curious side effect: with increasing velocity the protons also increase in mass, thus confirming once again an essential part of the Einstein Theory of Relativity. In the case of the CERN synchrotron, the protons increase in weight by 25 times.

Vacuum Chamber

The vacuum chamber is made of stainless steel 2 mm thick. In order to minimize collisions between protons and gas molecules, a total of 66 vacuum pumps are connected into the annular chamber, which reduce the residual air pressure to less than 10^{-6} Torr. For the installation of the 100 magnet units round the circumference of the 656-ft circle, the maximum geometrical tolerance was plus-or-minus 0.1 mm. This represents a ratio of $1:10^6$ for the position markers of the units. In order to attain this extremely high degree of accuracy, the annular tunnel was built on concrete piles, some going as deep as 30 ft into the ground to bedrock. The atmosphere in the tunnel is kept constant to within 1 degree C by a very efficient air-conditioning plant, in order to exclude any possibility of geometrical change due to thermal expansion. Since there is inevitably danger in the radiation produced in the acceleration process, massive baryte concrete shielding is installed and the entire circular tunnel housing the vacuum chamber covered with an earth embankment.

The power supply to this fabulous

The term GEV is used in Europe instead of BEV to denote billion electron volts, because the European billion is different from ours. In Europe a billion is a million million, whereas in the U. S. it is a thousand million. The G in GEV stands for gigantic and stems from the Latin *gigas*.

Aerial view of the CERN nuclear research laboratories. At the left can be seen the 25 thousand million electron-volt (25 Gev) alternating gradient proton-synchrotron. In the foreground are the experimental halls in which the experiments are carried out

machine is a story which cannot be described here, but some idea of what is involved can be had from the magnet requirements. The magnet current must be raised from zero to 6400 amp in 1.1 sec and reduced back to zero in 1 sec, during which time the magnet voltage must be kept constant to within, plus-or-minus 0.2 per cent. To control this exchange of energy a total of 24 grid-controlled mutators are employed. The peak power of 38,400 kw is supplied by a turbo-alternator driven by an induction motor. The speed of the motor is governed by an electronically-controlled Scherbius set.

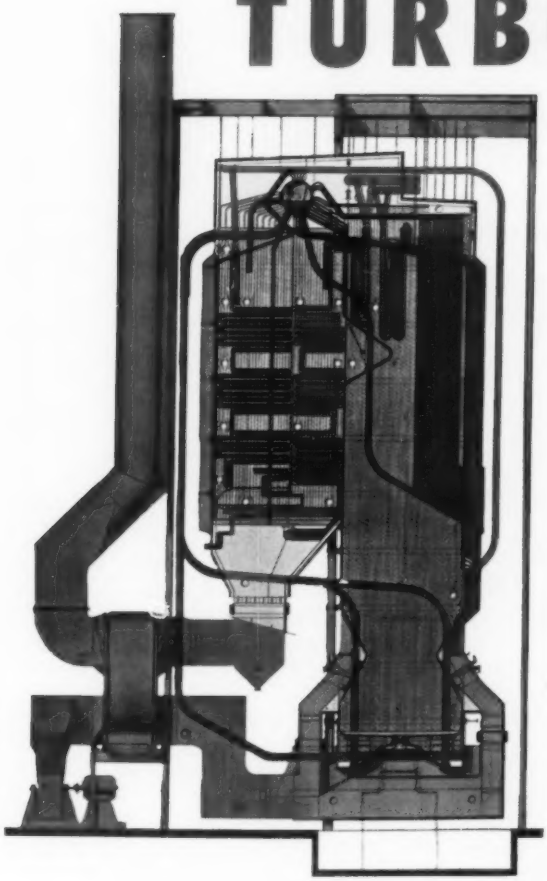
New Nuclear Literature

* * * * The population of the world is approaching three billion. If all these people were placed side by side and each person were shrunk to the size of an average atomic nucleus, the length of the resultant human chain would be about half as long as the thickness of the sheet of paper on which these words are printed. Ridiculous though this example may be, it does serve to bring out a fact which is vital to a thorough understanding of the principles of atomic physics and of nuclear engineering. If the nucleus is that small, how can it be measured? . . . It is the purpose of a new book, entitled *Nuclear Radiation Engineering*, to provide the reader with answers to such questions by having him develop an understanding of the techniques which have been employed by chemists and physicists to determine the dimensions and physical characteristics of atoms, nuclei, and nuclear particles as we know them.

. . . This book is for executives, supervisors, engineers, and others who are not specialists in nuclear science but who need a general knowledge of the subject in their daily work. It is written at an introductory level and includes ample scientific background information. The material, in fact, was originally prepared as a series of lectures for executives, supervisors, and engineers at the Boeing Airplane Company in Seattle. The book is simply and clearly written and is illustrated with simple diagrams. Part I (the first five chapters) reviews the methods which were used in establishing the structure of the atom. Part II (chapters 6 to 9) investigates radiation phenomena in terms of atomic and nuclear structure, and Part III, involving chapters 10, 11, and 12, deals with applications of radioactivity in terms of instruments, people, and things. Part IV provides a Dictionary of Atomic and Nuclear Terms and Phrases — some 500 terms in all. The author is Professor F. W. Hutchinson, University of California. This 155-page book is published by The Ronald Press Co, 15 East 26th St, New York, N. Y., and is priced at $6.00. * * * Ordinarily, we do not associate paper-backs — the small size paper-covered books found in racks in drug stores, in railroad stations, bus terminals, etc — with technical books. Recently, however, a number of very interesting technical, or perhaps we should say, semi-technical books have been appearing in paper covers, selling at prices ranging from 95 cents to $1.25. A notable example is *Project Sherwood — The U. S. Program in Controlled Fusion*, by Amasa S. Bishop. This was one of the 13 Geneva Presentation Volumes presented by the United States at the Second International Conference on the Peaceful Uses of Atomic Energy at Geneva in 1958, and which formerly sold for $5.75 in the hard-cover edition. Another fascinating volume that has made its appearance in paper-covers is a book by Donald J. Hughes, of Brookhaven National Laboratory. This is *The Neutron Story*, a "Doubleday Anchor Original," and one of a series of volumes on science being prepared under the direction of the Physical Science Study Committee of Educational Services, and published in coöperation with Doubleday-Anchor Books and Wesleyan University. Anyone who may have been intrigued by our discussion of the neutron in the January issue of ATOMICS will be delighted with this new book by Dr. Hughes. The neutron is the most potent, the most useful, and the most enigmatic of all the fundamental particles of matter-energy that fascinate today's physicists, and here, in this little book, step-by-step, is a clear account of the neutron's chain-reacting history and of its surprising behavior, in much greater detail than we were able to present it in the January ATOMICS. This book is written simply and clearly, for the intelligent layman. Dr. Hughes has written several other books on the neutron, but these former books are all of a technical nature. This new book is a popular treatise, devoid of all mathematics, and illustrated with beautifully clear diagrams. Nobody, is better qualified to write a book of this type on the neutron than Donald Hughes. He is one of the gifted young physicists who worked on the atomic bomb project during the war and thus helped to usher in the nuclear age. At the age of 43, Dr. Hughes is a senior physicist at Brookhaven, where he directs a group doing pile neutron research. He was extremely fortunate in being able to learn about neutrons directly from Enrico Fermi, with whom he was associated at the University of Chicago from 1942 until Fermi's death in 1954. As Dr. Hughes points out in the preface to his book, writing it was a most pleasant experience because it gave him an opportunity to pass on to many individuals the zest for penetrating the nature of matter so unfailingly displayed by Fermi. Although an integral part of the high school physics program, *The Neutron Story* deals with a special topic not included in the normal course work. In spite of its place in the teaching program, the book is written in such a way that its understanding does not depend upon classroom material. Actually, the author kept three rather distinct groups in mind. There are first of all the young students who will go ahead to do pioneering research on their own; secondly, those who are studying science in high school but will proceed to many non-scientific fields; and finally the general readers, pursuing no course work, who are interested in the meaning of modern science. *The Neutron Story* is published by Doubleday Anchor Books, Doubleday & Co, Inc, Garden City, N. Y., and is sold at all bookstores in the United States at 95 cents and in Canada at $1.10. It is available to secondary school students and teachers through Wesleyan University Press Incorporated, Columbus 16, Ohio. * * * Water has no cracks. This statement may seem somewhat silly, but it has considerable significance when used in connection with the problem of reactor shielding, and that is why it appears at the head of the foreword of the *Reactor Shielding Design Manual*. Shielding in the design of nuclear reactors is a necessary evil — expensive, often cumbersome and unwieldy but extremely essential. Poor shield design can lead to high costs, poor maintenance accessibility, high radiation levels near shield penetrations, or excessive stresses due to nuclear heating in structures near the reactor core. The *Reactor Shielding Design Manual* describes the procedures and data which are used in the design, construction, and testing of shielding for the reactor plants of the Naval Reactors Program and for the Shippingport Pressurized Water Reactor (PWR). These procedures are quite different from those practiced on other projects. The fact that these techniques — developed originally for naval reactor applications — apply so directly and so well to the PWR makes it apparent that this manual might be useful to other projects. Edited by Theodore Rockwell III, Technical Director of the Naval Reactors Branch, AEC, the *Reactor Shielding Manual* is published by McGraw-Hill Book Co, Inc; the price, $7.50.

Your Answer to Full Fuel Utilization in the '60's...

...RILEY Boilers With The TURBO FURNACE



Any fossil fuel can be fired in a Turbo Furnace singly and in any combination. Advanced operating and performance characteristics represent important strides in the art of fuel burning and steam generation. In recent years the Riley Turbo Furnace Boiler, a relatively new concept of boiler-furnace design, has been widely accepted by public utilities, manufacturing industries and their consulting engineers.

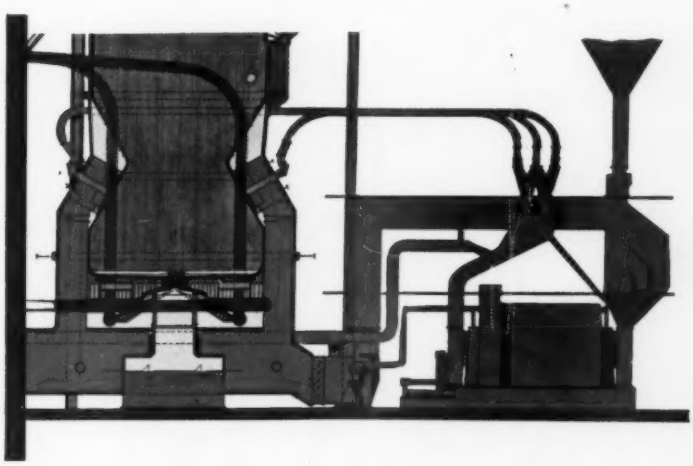
Turbo Furnace Boilers now in operation and under construction range in size from industrial type installations to high capacity central station units. Many Turbo Furnace Boilers are pressurized. Some are designed to fire coal, oil and gas separately or in any combination depending on B.T.U. cost of fuel.

Coal fired Turbo Furnace Boilers have these advantages: the elimination of the problem and cost of flyash disposal, the elimination of slag blowers, the ability to tap slag through a wide load range. Four Turbo Furnace Boilers are successfully firing fluid coke, which is handled as a pulverized fuel.

Many boilers of this design were purchased in anticipation of a changing fuel market because the design offers a simple low cost means of transition from one fuel to another.

The 1,650,000 lb/hr Turbo Furnace reheat boiler design for Louisiana Power and Light Company's new Little Gypsy Steam Electric Station . . . pioneer in complete automatic operation. Boiler operation at 2350 psig, 1005 F. superheat, reheat; pressurized.

Because the basic design of the Riley Turbo Furnace Boiler is suited to firing a wide variety of fuels, a boiler initially installed to burn oil and gas requires little alteration to equip it to burn pulverized coal. The design at right is a boiler originally installed for oil and gas. Many of the provisions for pulverized coal firing are accomplished externally while the boiler is kept in service on oil or gas.



A careful survey of your plant by a qualified consulting engineer could show ways of making substantial savings in power costs.

RILEY

STEAM GENERATING & FUEL BURNING EQUIPMENT

Here Are Some Desirable Characteristics You'll Find In A Riley Turbo Furnace Boiler

Simplified Steam Temperature Control

Performance varies little with type and grade of fuel being burned. Furnace exit temperature is lower than for horizontally fired boilers of equal heat release rates because heat absorbing surfaces are used more effectively. This simplifies steam temperature control.

Reduces Flyash Problems

Reinjection of flyash and continuous molten ash discharge eliminate costly flyash collection and disposal problems. Flyash combustible losses are eliminated. Some installations receive flyash from adjacent dry bottom units for disposal in the Turbo Furnace.

Reduction of Air Pollution

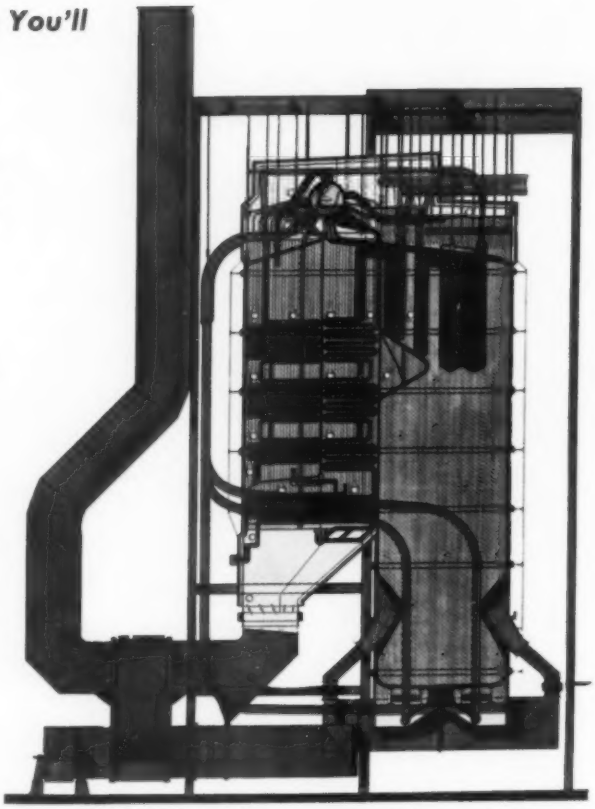
Because of the burning method, flue gases contain lower quantities of objectionable oxides of nitrogen.

Continuous Slag Tapping At Low Loads

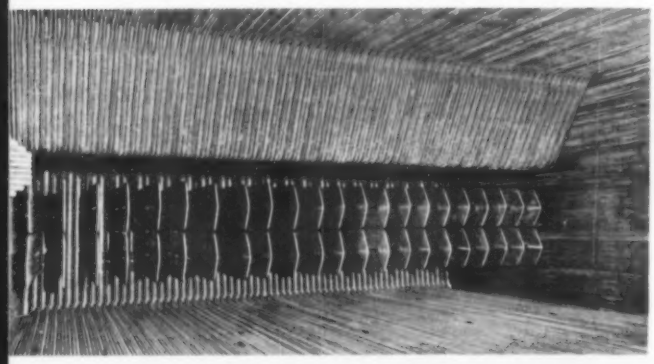
Burners are directed downward and fire on the floor around the tap hole assuring tapping at low load operation and making possible the use of higher fusion coals. Continuous flow of slag has been obtained at 25% of maximum continuous rating.

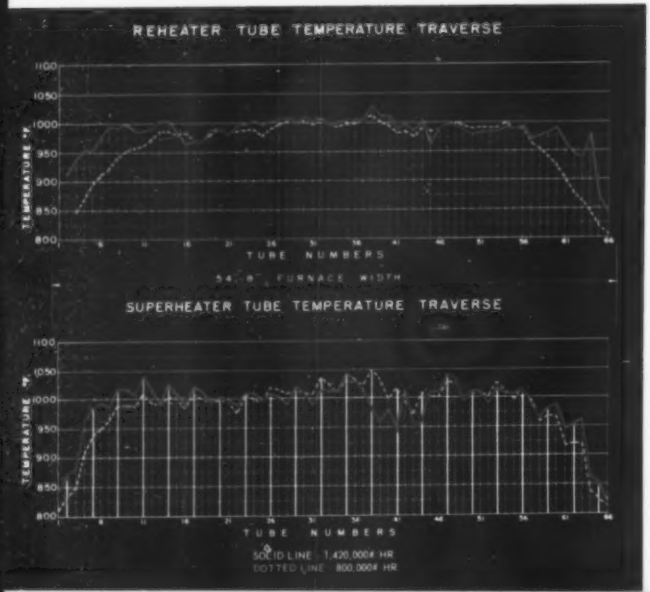
No Furnace Wall Deslaggers are Normally Required

Because of high ash retention in the bottom and the uniform vertical gas flow pattern furnace wall slagging is substantially eliminated.



The 1,550,000 lb/hr Turbo Furnace Boiler at Louisiana Power & Light Company's Sterlington (La.) Steam Electric Station, 2125 psig, 1005/1005 F pressurized. At left—View across 55 foot wide furnace at superheater elevation.





Higher Heat Releases Permitted

The fuel is burned within the Turbo Furnace bottom, just above the Turbo Furnace floor . . . the entire furnace wall area is available for heat recovery. The nominal heat release may thus be higher than for horizontally fired boilers.

Lower External Structure Cost

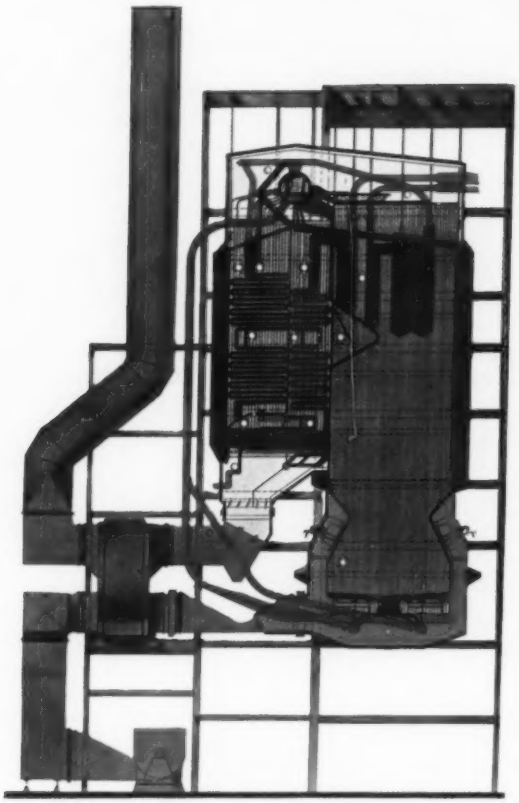
With lower furnace heat releases permitted the Riley Turbo Furnace boiler occupies less cubical space. One burner level eliminates platform and ladder construction costs.

Wider Single Furnace Boiler Units Permitted

Furnace design, combined with the opposed method of firing, controls gas flow pattern to remove limitations on furnace widths inherent with other methods of firing. Gas temperature traverses at the furnace exit are extremely uniform.

Minimum Metal Temperature Variations Due To Uniform Gas Flow

The view at left and chart are of the 55 foot wide single furnace of the 1,550,000 lb/hr unit above. Furnace has no division walls or platens. The chart shows the uniform metal temperature gradient of superheater and reheater tubes spaced across the width of the furnace. The maximum variation above the normal 1005 F is well within safe limits assuring long metal life. The chart also shows the same uniform pattern for lower loads.

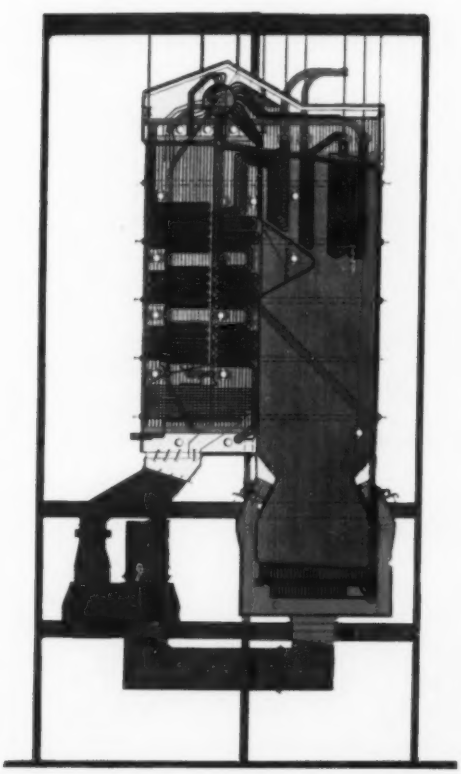


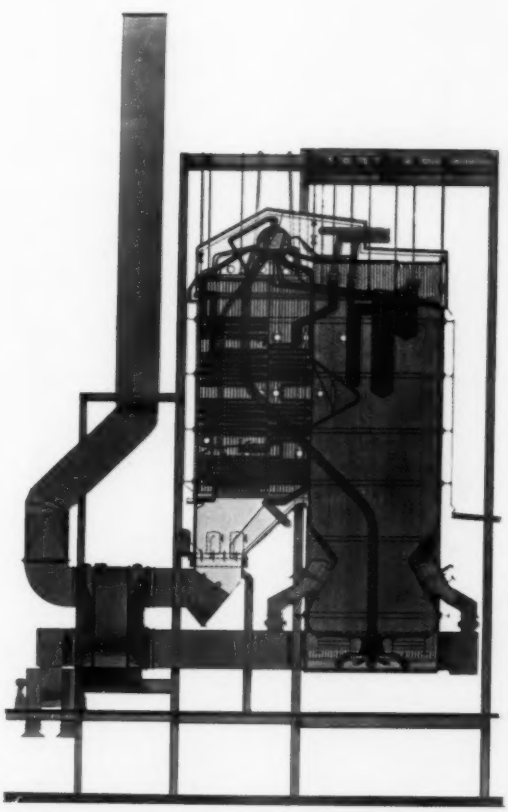
TYPICAL RILEY TURBO FURNACE BOILER INSTALLATIONS

At left — North Lake Steam Electric Station, Dallas Power & Light Company. 1,200,000 lbs/hr — 2125 psig, 1005/1005 F with pressurized Turbo Furnace. Fired by natural gas and oil.

Lower left — Turner Unit No. 4, Florida Power Corporation. 600,000 lbs/hr—1650 psig, 1000/1000 F. Fired by oil and natural gas.

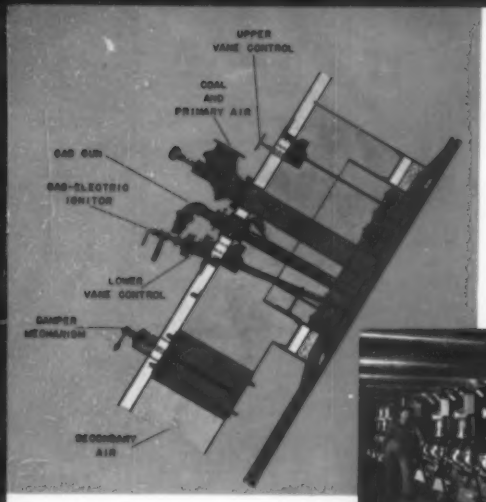
Below — Permian Basin Steam Electric Station, Texas Electric Service Company, 825,000 lbs/hr, 1750 psig, 1005/1005 F. pressurized. Fired by natural gas, oil, (Future pulverized coal).

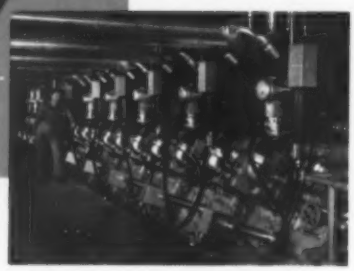




RILEY

STEAM GENERATING & FUEL BURNING EQUIPMENT

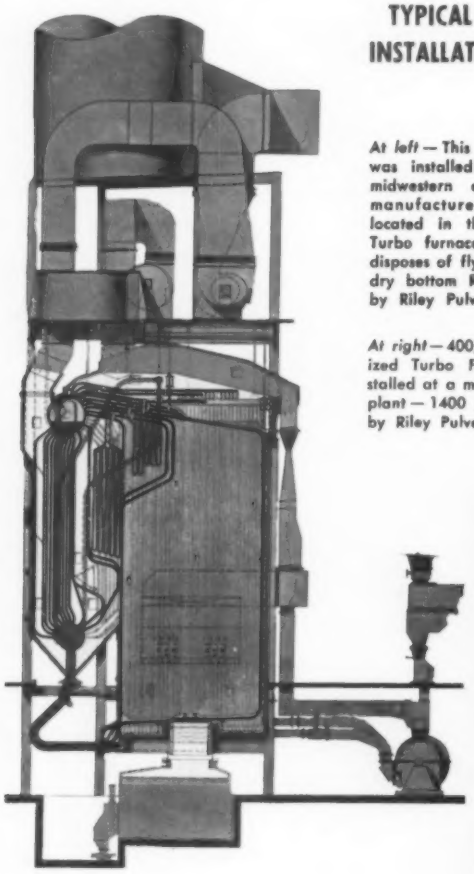




Turbo Furnace Burner Maintains Stable Flames Over Wide Load Ranges.

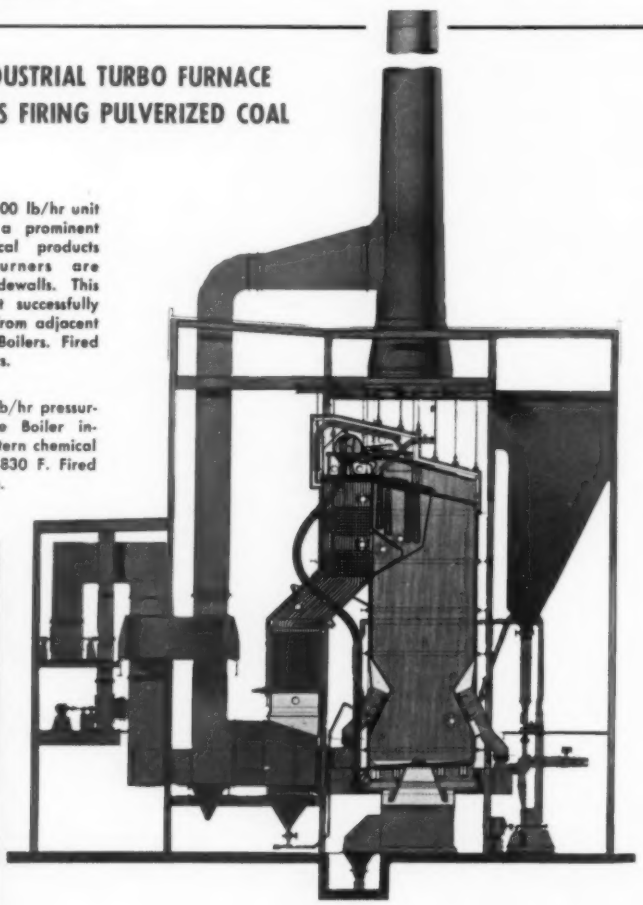
Riley Directional Flame Burners are designed expressly for the Turbo Furnace to burn gas and oil and pulverized fuels that are burned in suspension such as coal, lignite, fluid coke, delayed coke, etc. Burners are arranged for opposed firing on one level. Fuel and combustion air are introduced thru openings between furnace wall tubes. There is no exposed refractory to maintain. Directional vanes control placement of flame. Turn down ratio for gas is limited by gas flow control system; minimum load for oil is limited only by oil atomization (7 to 1 ratios have been attained). Stable flames with coal firing are easily maintained on a 5 to 1 load ratio.

TYPICAL INDUSTRIAL TURBO FURNACE INSTALLATIONS FIRING PULVERIZED COAL



At left — This 150,000 lb/hr unit was installed by a prominent midwestern electrical products manufacturer. Burners are located in the sidewalls. This Turbo furnace Unit successfully disposes of flyash from adjacent dry bottom Riley Boilers. Fired by Riley Pulverizers.

At right — 400,000 lb/hr pressurized Turbo Furnace Boiler installed at a midwestern chemical plant — 1400 psig, 830 F. Fired by Riley Pulverizers.



Ask your Riley representative for detailed information about Riley Turbo Furnace Boilers — or write direct to RILEY STOKER CORPORATION, WORCESTER, MASSACHUSETTS.

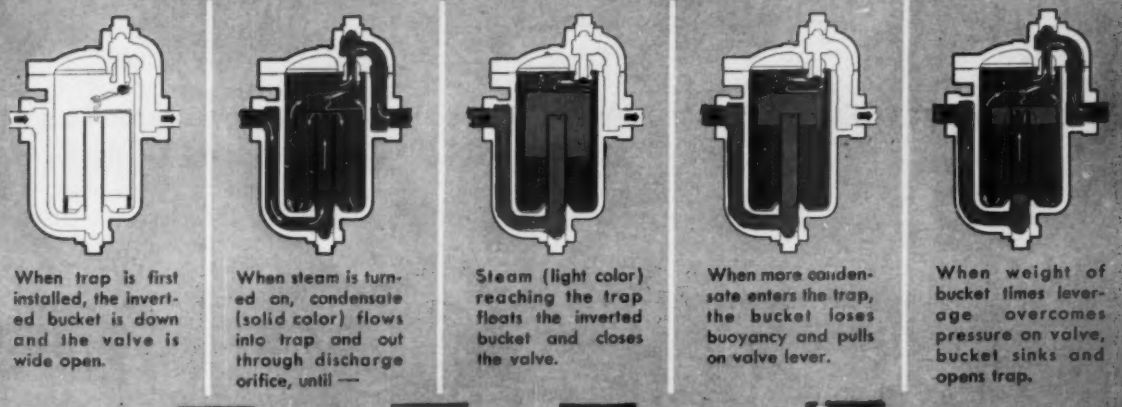
RILEY

STEAM GENERATING & FUEL BURNING EQUIPMENT

SALES OFFICES

Boston, Charlotte, Chicago, Cincinnati, Cleveland, Detroit, Houston, Jacksonville, Kansas City, Los Angeles, New Orleans, New York, Philadelphia, Pittsburgh, Portland, Salt Lake City, San Francisco, Seattle, St. Louis, St. Paul, Syracuse.

This simple trap operating principle provides the efficiency, dependability and freedom from maintenance necessary for the most profitable use of steam



When trap is first installed, the inverted bucket is down and the valve is wide open.

When steam is turned on, condensate (solid color) flows into trap and out through discharge orifice, until —

Steam (light color) reaching the trap floats the inverted bucket and closes the valve.

When more condensate enters the trap, the bucket loses buoyancy and pulls on valve lever.

When weight of bucket times leverage overcomes pressure on valve, bucket sinks and opens trap.

Key: condensate steam steam bubbles air bubbles

ARMSTRONG
INVERTED BUCKET STEAM TRAPS
are designed and made to give you these big benefits:

● Amstrong Traps, the first inverted bucket steam traps, now represent the most advanced development of this time-proven principle. They provide all the advantages necessary for efficient, economical condensate drainage from virtually all types of steam using equipment.

1. *No steam loss* – Steam never reaches the orifice even when there is no condensate load.
2. *Automatic air elimination* – Vent in trap bucket passes air and other non-condensibles through to be discharged with condensate.
3. *No cooling leg required* – Condensate is discharged at steam temperature as fast as it reaches the trap because trap operates on difference in density between steam and water not on temperature.
4. *Operates on any back pressure* – Failure of one trap in system will not cause others to open because high back pressure does not affect an Armstrong trap other than to reduce capacity. As long as there is a pressure differential across the orifice the trap will close on steam and open for condensate.
5. *Unaffected by ordinary dirt* — Swirling action of condensate keeps dirt in suspension until discharged with condensate, prevents it from lodging in valve.
6. *Completely dependable* — Proved design plus the use of all stainless steel working parts assure continuity of service and length of service unmatched by any other trap.
7. *Big capacity in a small, economical package* — Armstrong design gives you the highest practical capacity for any given pressure. And remember, Armstrong capacity ratings are based on *hot* condensate at the *working pressure differential* stated, not on theoretical orifice capacities.

Further information on these advantages plus much additional information is given in the 48 page Armstrong Steam Trap Book. Ask your local Armstrong Representative or write direct.

860 Series for low pressure heating service.

800 Series, side inlet, side outlet.

No. 801, side inlet, bottom outlet.

880 Series, integral strainer.

200 Series, bottom inlet, top outlet.

Forged Steel Series for high pressures, high temperatures.

The 48 page Armstrong Steam Trap Book tells how to correctly size, install and maintain steam traps for any pressure, any temperature, any load plus full catalog data on Armstrong Steam Traps. Ask for Catalog K.

ARMSTRONG MACHINE WORKS
8107 Maple Street Three Rivers, Michigan
"SEE OUR CATALOG IN SWEET'S PLANT ENGINEERING FILE"

For more data circle 532 on Post Card

cost

CONSOLIDATED SAFETY VALVES relieve overpressures automatically at extremely low cost per pound of steam discharged

Consolidated Safety Valve, Type 1511 Series. Cast iron body. Maximum capacity for saturated steam. Sizes: 1½" thru 6". Pressures to 250 psi. Temperatures to 450° F. ASME Standard. ASME Tested. National Board Certified.

conscious

Cost-conscious engineers provided maximum capacity in minimum flange size when designing the compact Type 1511 Consolidated Safety Valve. This innovation makes it practicable to reduce the number and/or size of safety valves per boiler. You also have the advantage of smaller, less costly discharge piping.

Fine blowdown adjustment, few working parts, and the positive tightness of optically flat seating add to the total economy of these tough, long-life valves. Get complete technical data and select from the Type 1511 Series the Consolidated Safety Valves that best meet your needs. Write for Bulletin 730.

Industrial distributors in all principal cities are backed by our convenient regional warehouses to give you prompt delivery on the Consolidated valves of your choice.

MAXWELL MANNING M&M & MOORE INC. TRADE MARK

CONSOLIDATED SAFETY VALVES

A product of

MANNING, MAXWELL & MOORE, INC.

Consolidated Ashcroft Hancock Division • Stratford, Connecticut
In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

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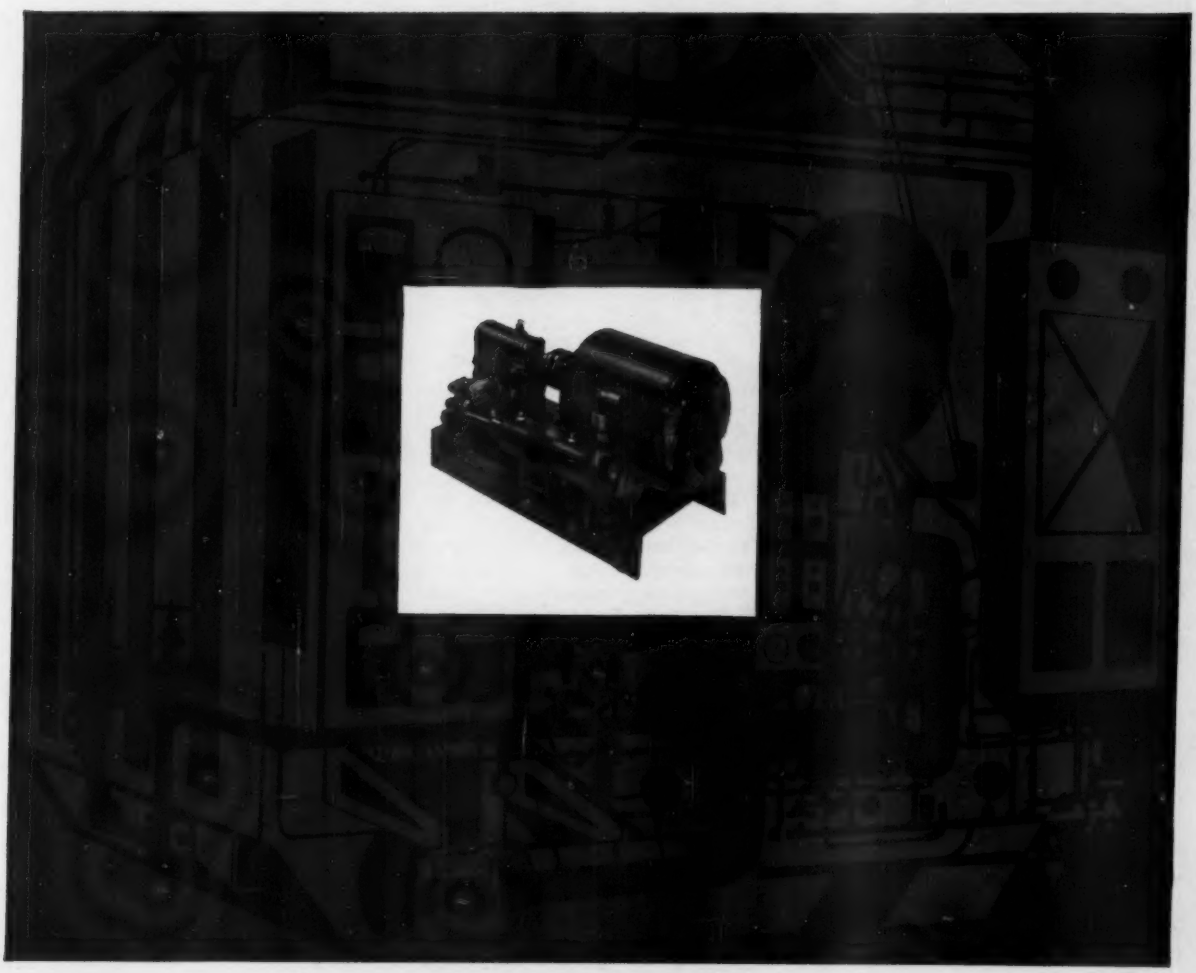
GET LOW-COST DEPENDABLE PROTECTION FOR LOW PRESSURE BOILERS WITH AN H20® CHEMICAL METERING PUMP

Benefits include lowest cost ever, a new record for low maintenance requirements, and easier servicing. The H20 controlled volume pump not only costs less to purchase and install, but it costs less to operate at the peak of efficiency than any other comparable chemical feeder. The H20 metering pump is based on the same principles that have made Milton Roy controlled volume pumps famous. But in the interests of economy, every working part has been simplified and redesigned for production line manufacturing. There's been little sacrifice in accuracy, and none at all in dependability.

Around the clock, you can depend on your H20 pump to meter the necessary mild, non-corrosive treatment chemicals to your boiler feed, cooling tower, and process make-up water. The H20 is available immediately from stock. Even completely piped and assembled chemical feed systems with simplex or duplex H20 pump and 50 or 100 gallon steel tank can be shipped within 24 hours. They're ready to go to work immediately, accurately and economically metering chemicals against pressures to 600 psi.

GET COMPLETE FACTS *on the H20 pump and packaged chemical feed systems in Bulletin 558. Write Milton Roy Company, 1300 East Mermaid Lane, Philadelphia 18, Pennsylvania.*

milton Roy
CHEMICAL INSTRUMENTATION SYSTEMS



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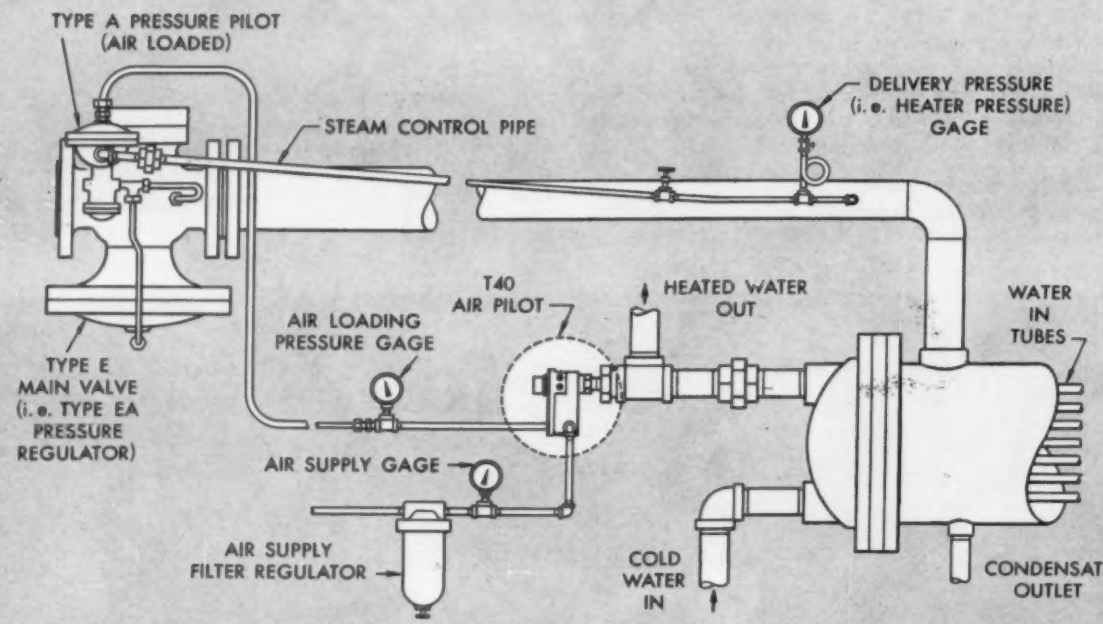
New Spence Temperature Control System Gives Unusual Control Accuracy


TYPE A PRESSURE PILOT (AIR LOADED)
STEAM CONTROL PIPE
DELIVERY PRESSURE (i. e. HEATER PRESSURE) GAGE
T40 AIR PILOT
HEATED WATER OUT
WATER IN TUBES
AIR LOADING PRESSURE GAGE
TYPE E MAIN VALVE (i. e. TYPE EA PRESSURE REGULATOR)
AIR SUPPLY GAGE
AIR SUPPLY FILTER REGULATOR
COLD WATER IN
CONDENSATE OUTLET

TYPE EAT40 AIR-CONTROL TEMPERATURE REGULATOR (Patent Pending)

In a recent installation the new Spence air-control temperature regulating system provided:

- ±5°F control accuracy under wide and instantaneous load swings of 210 to 80 gallons per minute.
- Up to 50% reduction in cost as compared to instrument systems of similar accuracy.

This unique cascade-type control with throttling range adjustment independent of maximum heater pressure was developed to meet today's demand for greater control accuracy.

Additional features of the new Spence Temperature Control System include:

- 200°F wide adjustable temperature range
- Adjustable speed of steam pressure change
- Over and under temperature protection
- Pressure limit control
- Fast response
- Very low air consumption
- Field reversible for heating or cooling

The Spence Type EAT Air Control Temperature System, when properly installed, will tame wide ranging, fast changing loads of instantaneous heaters and modern heat exchangers. The cascade principle plus the use of an extremely fast responding bi-metal temperature sensing element reduce time lags and provide control stability.

Here's how the new Spence system operates:

Quick response is based on a bi-metal temperature sensing element.

Temperature pilot continuously regulates a loading air pressure.

This loading signal, when applied to a pressure regulator to reflect heater temperatures, causes it to adjust the main valve as changes in load require.

Spence has also developed a new pressure control system based on this same cascade principle. This system has a control accuracy of ½ psi or better from positive pressures through the vacuum range to 30" Hg.

For complete information on these new air controlled temperature and pressure control systems, write for your copy of Bulletin 9.

SPENCE ENGINEERING COMPANY, INC.
Walden, New York 55-148

For more data circle 535 on Post Card

Hall Industrial Water Report

VOLUME 8 APRIL 1960 NUMBER 2

How to Increase Your Salary

Water's insatiable appetite for iron and other commonly used metals and alloys is costing industry many millions of dollars every year. Effective treatment of water to reduce corrosion to a minimum can save a substantial chunk of these dollars and route them into the till. Thence into the stockholder's pocket as dividends and into your pocket as a reward for cutting costs.

Hall engineers know how to treat water to combat its attack of metals. They can help you save many of the dollars that are being spent for maintenance and repairs because of avoidable corrosion.

Elusive Oxygen

Sodium sulfite feed for chemical fixation of residual dissolved oxygen in the boiler feedwater at a southern paper mill is usually less than twenty pounds per day. A sudden threefold jump in the requirement puzzled the operators. The increase in dissolved solids necessitated more blowdown which, in turn, increased requirements for other water conditioning chemicals.

When Hall engineer T. W. Hubner was called in, the symptoms indicated either trouble in the deaerating heater or bypassing of the heater with water high in dissolved oxygen. The second possibility was the easier to check.

A search by the operators then located the trouble. A valve in a bypass line was partially open which accounted for the difficulty. When the valve was closed, water conditions returned to normal. Experience enabled Hubner to steer the search in the right direction.

Luxury Pays Off

An aluminum fabricator was forced to reduce production several times per year for removal of corrosion products from inert gas coolers. Water treatment to control the corrosion in the cooling system had been considered. However, the operation was a small one and it was felt that water treatment was a luxury.

Hall engineers surveyed the cooling water problem and found that the cooling system could be protected at a cost of less than sixty cents per day.

Results have confirmed the findings. The annual cost of water treatment, which now permits uninterrupted production, is less than the previous cost of a single heat-exchanger outage.

Unusual Corrosion Problems

Peculiar corrosion effects sometimes result from contact of acid and steel. They are of interest because they might be encountered in connection with acid cleaning or in equipment used to store and handle acid for water treatment.

Although the rate of reaction between 66° Baume sulphuric acid and steel is substantially nil, it is greatly accelerated if moisture is picked up from the atmosphere. Bubbles of hydrogen, generated by corrosion, presumably become detached from the metal, rise and accumulate in contact with metal at such locations as horizontal pipe. Resulting erosive and galvanic effects impair the normal protective oxide coating. Narrow, but sometimes deep, grooves can be produced.

Hydrogen blistering has been observed near or just above the liquid level in concentrated sulphuric acid storage tanks and in pickled steel. Atomic hydrogen from corrosion diffuses through the metal. Where the hydrogen atoms meet something that catalyzes the formation of molecular hydrogen, the larger molecules cannot pass on through the metal. Accumulation of gas occurs and pressure becomes high enough to tear apart the metal grains. Failure tends to proceed along planes of stress which are predominantly parallel to the surface in steel plate, so characteristic gas blisters result.

Rain Water in Compressor Coolers

Decreasing supplies of surface and ground water in eastern gas fields have forced compressor operators to rely heavily on rain water storage to provide water for cooling system makeup. This has resulted in rapid corrosion of black iron pipe and formation of heavy organic deposits on heat-exchange surfaces.

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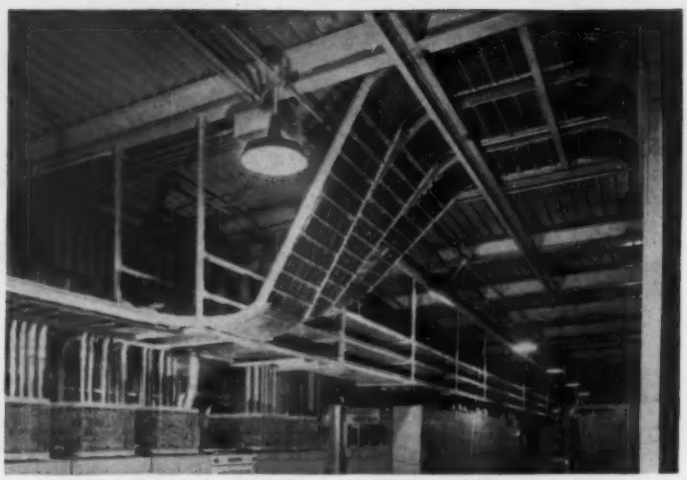

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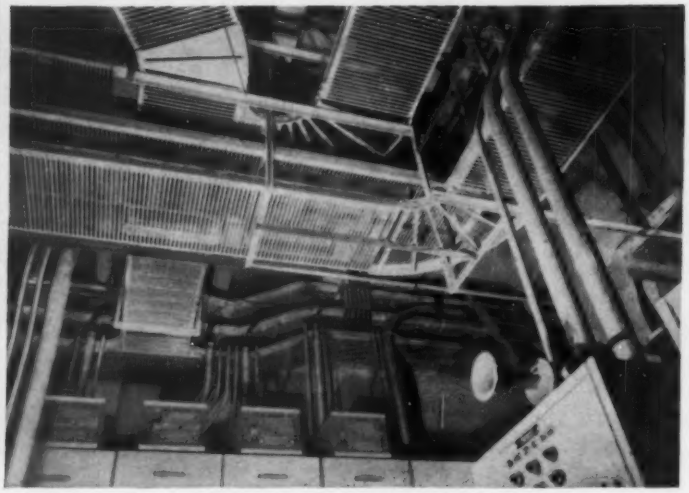
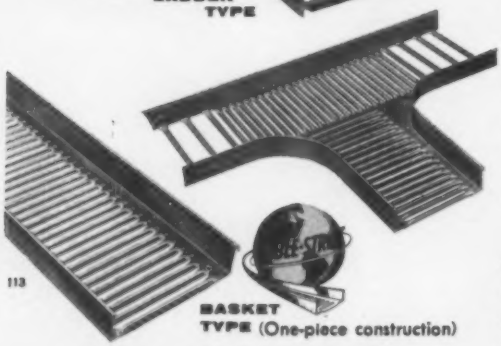


Globetray Pat. Pending

LADDER TYPE



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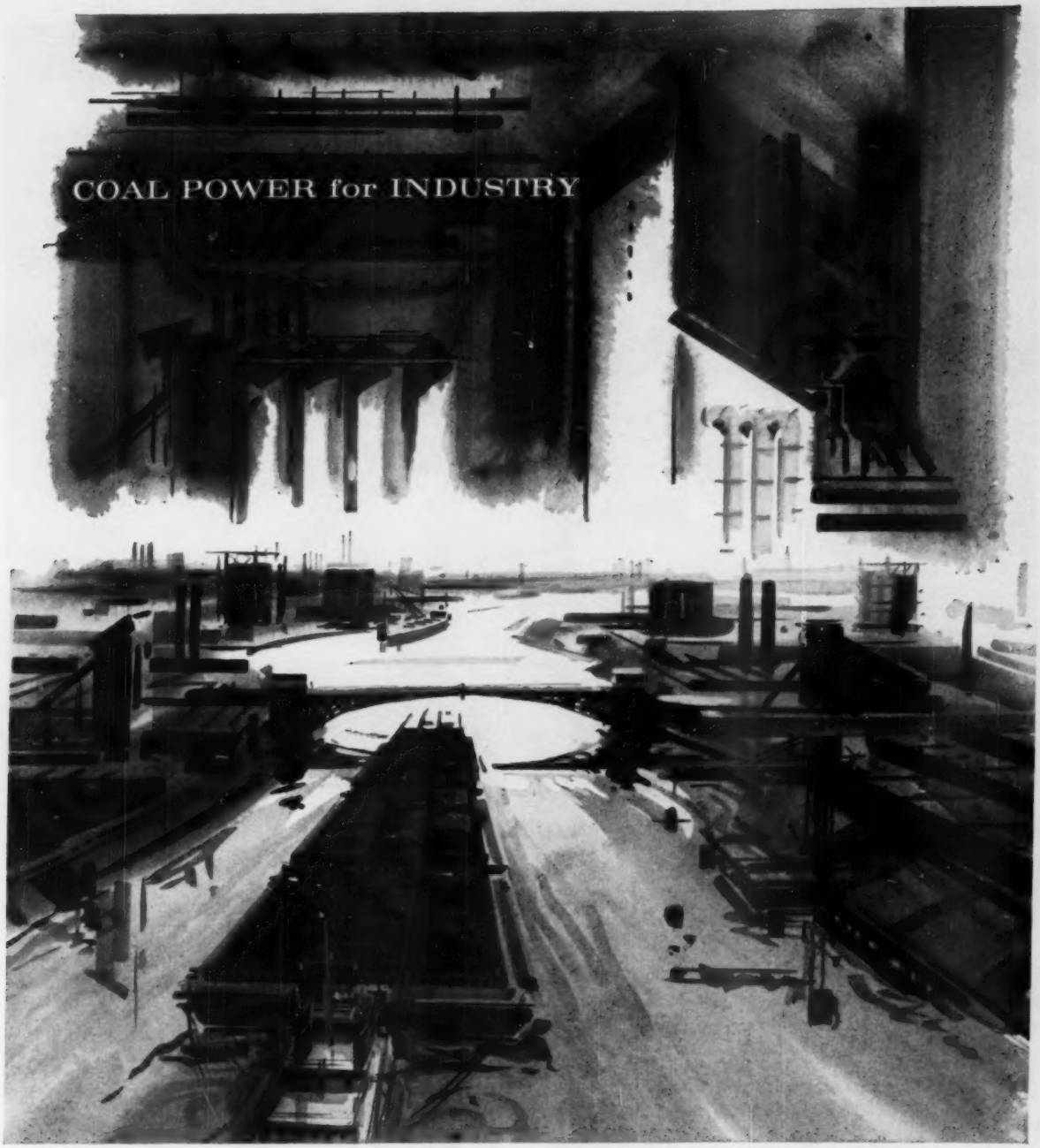

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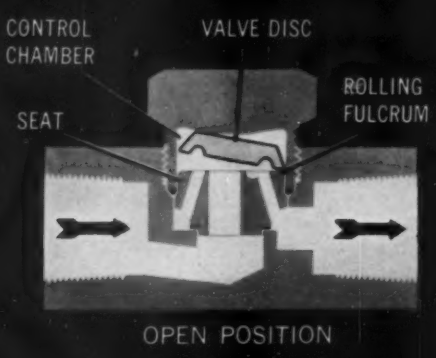

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TRACERS

Power Engineering's Monthly Probe of Power Facts

What is MHD? It holds out the glowing promise of boosting the efficiency of thermal power generation from today's 40 per cent to a sensational 55 per cent. It's based on the principle of generating electricity directly from heat by passing hot gases through a magnetic field. It's a development every power engineer should follow closely. Start by reading John Yellott's article on MHD, page 72 of this issue.

General Electric Co's experimental extra high voltage transmission line near Pittsfield, Mass., will be energized by May at 460,000 v. Eventually, GE will experiment with 750,000 v, the highest transmission voltage in the world. Since the mid-1940's there has been an upsurge in the use of EHV power transmission. There are at present more than 12,000 circuit miles of 275- to 500-kv power lines in operation or under construction. U. S. has 25 per cent of this, the Soviet Union, 20 per cent.

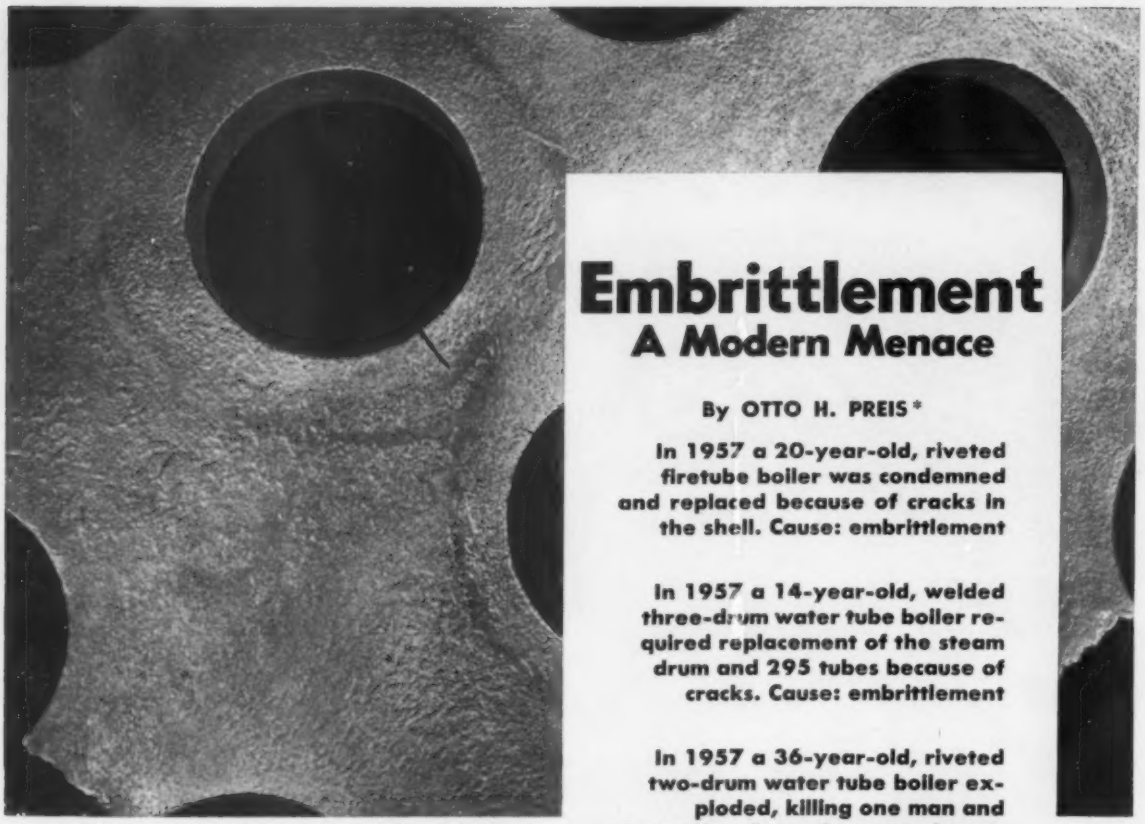
Mile-long test section of aluminum pipeline for delivery of natural gas has been installed by Columbia Gulf Transmission Co. Hydrostatically tested at 1250 psi, the line is now moving gas at 1000 psi. If aluminum proves to be satisfactory, it will eliminate the expense of coating and wrapping the pipe before it is buried.

Hypervelocity impulse wind tunnel is planned at McDonnell Aircraft Co, which will make possible investigation of thermal and aerodynamic properties at speeds of from nine to 24 times the speed of sound, and at simulated altitudes above 100,000 ft. Power plant for this facility will be an energy storage system built by Westinghouse and capable of delivering electrical power at the average rate of 2⅓ million kw — more than six times the rating of the largest turbine generator.

Calculation of nuclear fuel costs is not quite as easy a task as the calculation of conventional fuel costs, because such things as the chemical reprocessing of the spent fuel and its transport to the reprocessing plants has to be taken into consideration. However, if these factors are all properly handled, nuclear fuel costs can be calculated with considerable accuracy. In ATOMICS, page 48 of this issue, H. L. Rubinstein tells exactly how to go about it.

New static excitation system which eliminates moving parts for ease in maintenance on medium capacity steam turbine generators has been developed by G-E. Servicing, if necessary, can be undertaken without removing the load from the generator. Power is obtained from connection to generator terminals, instead of from the mechanical drive of the shaft.

Republic Steel has in pilot production a new process for producing strip steel from powdered iron ore, which dispenses with coke ovens, open hearths, blast furnaces, and blooming mills. The ore is purified and reduced to a metallic powder, then compressed into a semi-solid strip, then heated to 2200 F and passed through a series of hot strip rolling stands.



Embrittlement
A Modern Menace

By OTTO H. PREIS*

In 1957 a 20-year-old, riveted firetube boiler was condemned and replaced because of cracks in the shell. Cause: embrittlement

In 1957 a 14-year-old, welded three-drum water tube boiler required replacement of the steam drum and 295 tubes because of cracks. Cause: embrittlement

In 1957 a 36-year-old, riveted two-drum water tube boiler exploded, killing one man and destroying the entire powerhouse. Cause again was embrittlement

Fig. 1. Embrittlement cracks in a 1-in. plate. Cracking in this drum was so extensive that it had to be replaced

THESE INSTANCES are among the most costly and disastrous cases of embrittlement occurring in 1957. Other cases of embrittlement were detected that year before extensive damage could occur. The year 1957 was not an unusual one for embrittlement except to the plants involved. Most of us, today, think of embrittlement as something that used to happen in the "horse and buggy days" of steam generation. However, each year another group of boiler operators finds out, sometimes in a very costly or disastrous manner, that embrittlement is still with us.

It is true that caustic metal embrittlement has steadily declined as a major source of worry for boiler operators for the following reasons:

1. Improved boiler designs and fabrication techniques have reduced boiler leakage, one of the conditions leading to embrittlement.
2. The embrittlement detector shows an operator if his boiler water is embrittling.
3. Proper use of nitrate or coördinated pH-phosphate control effectively inhibits embrittlement.
4. Widespread use of improved methods of water treatment has eliminated, in some cases, the embrittling characteristics of boiler waters.
5. Practically all of the plants which had experienced embrittlement in the past have been using proper protective treatment since embrittlement was first discovered.
6. Some organizations (perhaps because of past experience) apply protective treatment to all of their installations, old or new, as a matter of company policy. They regard the cost of the chemicals as cheap insurance against possible loss of life, loss of production, and loss of their powerhouse.

All of these factors have reduced our awareness of embrittlement as one of today's problems.

Embrittlement *is* one of today's problems. Any plant not using protective treatment, or any plant which has changed operating conditions or water supplies since its last embrittlement detector test, could become a statistic or be liable for a costly repair bill next inspection.

Plants which have operated with no difficulty for 14, 20 or 36 years are no exception, but old age is no prerequisite for embrittlement. Caustic metal cracking has been found in boilers only *30 days old*.

History and theories regarding embrittlement have been thoroughly covered in the past. Method of detection and methods of protective treatment have also been well covered in the literature. Since embrittlement is still with us, these methods of detection and control should again be emphasized.

Embrittlement detector shown in Fig. 4 is the apparatus used to determine if a boiler water is embrittling. It is still not possible to predict embrittling characteristics from the chemical analysis of a boiler water. ASTM designation D807-52 is the Standard Method of Corrosivity Test of Industrial Water (United States Bureau of Mines Embrittlement Detector Method).

Test bar is exposed for 30 days in the detector, and then check tests are run for 60 days and 90 days. If the bar shows cracks during the test, or shows cracks when it is further stressed by the investigating laboratory, the water is embrittling and protective measures should be applied. If no cracking occurs, 90-day

*Betz Laboratories, Inc

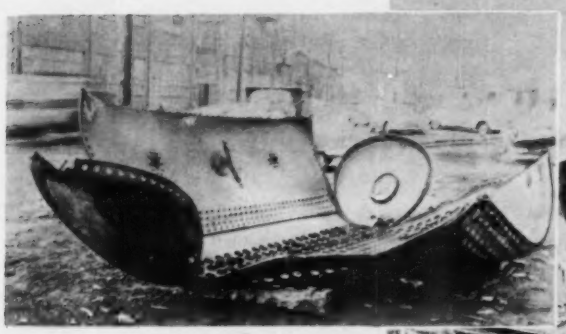


Fig. 2. Mud drum of a boiler which exploded because of caustic metal cracking

Fig. 3 proves how costly caustic metal cracking can be. This wreckage of the entire powerhouse is the aftermath of the explosion pictured in Fig. 2. Caustic metal cracking caused weakening of boiler seam until it could no longer withstand the normal operating pressure

check tests are run yearly or when changes are made in operating conditions or water characteristics.

Very reliable results can be obtained from the detector with careful handling and adjustment during the test. In some cases the 30-day and 60-day test bars showed no cracks while the 90-day test bar cracked completely after only one or two weeks' exposure. This phenomenon can occur as operating personnel become more proficient in the operation of the test unit and eliminate personal error. Accurate reporting of conditions of the test unit during the test run will help the investigating laboratory to determine if the test is valid.

Report of a cracked bar does not mean it is necessary to abandon the boiler house or seek a new water supply. A far simpler solution is available: the feed of *sodium nitrate*. Sodium nitrate has been inhibiting embrittlement for many years. Practically no cases of embrittlement have occurred or shown up on the embrittlement detector test when sodium nitrate was properly applied.

While nitrate is naturally present in many water supplies, the inhibition of embrittlement requires a definite ratio of nitrate to the caustic alkalinity present in the boiler water. Formula for calculating this sodium nitrate/sodium hydroxide ratio in boiler water is:

$$\frac{\text{NaNO}_3/\text{NaOH ratio} = \text{Nitrate as NO}_3\text{, ppm} \times 2.14}{\text{M.O. alkalinity as CaCO}_3\text{, ppm} - \text{Phosphate as PO}_4\text{, ppm}}$$

Ratios recommended by the U. S. Bureau of Mines depend on the operating pressure and are as follows:

	$NaNO_3/NaOH$ ratio
up to 250 psi	0.20
up to 400 psi	0.25
up to 700 psi	0.40

While sodium nitrate has been used to inhibit embrittlement at pressures as high as 900 psi, boilers operating with evaporated or deionized makeup can successfully use *coördinated pH-phosphate control* to prevent embrittlement.

Coördinated pH-phosphate control prevents the boiler water from developing embrittling characteristics by eliminating *free* sodium hydroxide from the boiler water. Since it is desirable to avoid low pH in the boiler water, proper pH is provided through the use of an agent such as trisodium phosphate.

Figure 5 illustrates the approximate pH of solutions of trisodium phosphate of various PO_4 content. To insure the absence of free sodium hydroxide and the absence of any alkalinity other than that of trisodium phosphate, it is necessary to maintain the pH of a boiler water below the curve.

This coördinated pH-phosphate method of preventing embrittlement is primarily applicable to plants employing evaporated or deionized make-up water. Although the curve in Fig. 5 can be used as a guide in the control of this method of preventing embrittlement, it is advisable to check on the hydroxyl ion content of the boiler water.

Thanks to the work of Professor F. G. Straub and the work done by W. C. Schroeder and A. A. Berk of the U. S. Bureau of Mines, we now have available information on the theory of caustic metal embrittlement, successful methods of detecting caustic metal embrittlement before damage occurs, and successful methods of preventing caustic metal embrittlement. THE END

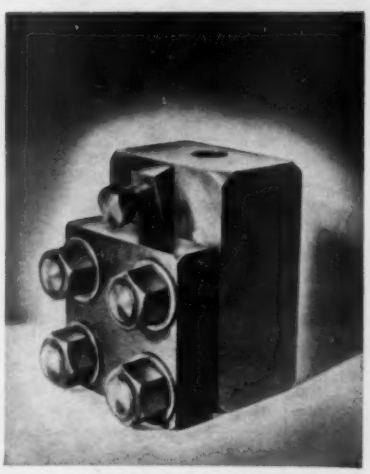


Fig. 4 shows an embrittlement detector

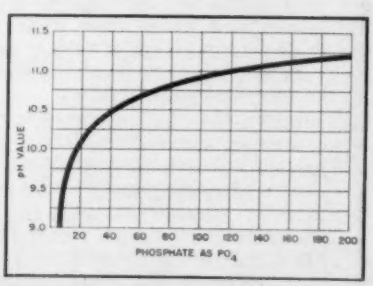


Fig. 5. Curve shows approximate pH values of trisodium phosphate solutions

CHANGING SHAPES . . .

Full Power Plant Automation

Another leader in the control field comments on the various points brought out by twelve top men in the automation field in the January issue. He analyzes the ways in which both analog and digital procedures can and should develop for best results

ADVENT OF PRACTICAL commercial digital logging, computing, and control equipment is producing revolutionary changes in the techniques of power plant operation. The nature of these changes is predicted by many informed people to range all the way from an improvement of analog techniques due to the pressure of digital capability, to the complete shift to digital techniques of physical measurements, data-gathering computation, automatic control during a normal operation, automatic start-up and shutdown, safety systems, and automatic maintenance programming. The probable course of such changes will fundamentally be a gradual one, with excesses toward and away from the newer techniques, reminiscent of the past experiences when really new concepts have been introduced.

Digital enthusiasts claim that the miracles to come are limited only by the lowly qualities of presently available hardware for inputs and outputs. Analog backers might answer that the limitations of physical measurements have always been the ceiling placed on analog computing and control performance.

It is perhaps safest to say that the most sophisticated and reliable digital equipment cannot produce a successful installation without a fair measure of experience and knowledge of the problems of plant operation and control. Where the fundamental inputs and outputs are both necessarily analog, there appears to be less motive for digital technique than in those applications where the desired outputs must be digital or where the input information is fundamentally of digital nature.

One might, therefore, make a guess that record keeping and the computation related to record keeping, alarm and safety interlocks, plus the automatic control of start-up and shutdown would be the best targets for digital treatment. Perhaps the majority of closed loop (normal load operation) automatic controls are better suited to analog methods. There will also be certain control functions whose sources of information will be found in the digital computing section and whose final results must influence the analog control loops of such an installation.

Rate of application of many of these concepts will be very strongly dependent on the careful design of new and the modification of existing transducers for converting physical measurements into suitable signals for both analog and digital equipment.

Fundamental requirement for continuous reliable operation of electrical utility units has often produced the philosophy that a power plant unit, somewhat like a government, should have some sort of multiple path system of checks and balances. An example of this would be an independent set of control equipment separate from record keeping and display instrumentation such that failure of part or all of either system would not necessarily result in a shutdown.

In this way, the failure of some automatic control equipment could be bridged over by manual manipulation using the separate instrumentation as an operating guide, while the failure of pure instrumentation would not in any way affect the automatic operation of a plant whose control was still functioning properly. There is, therefore, some understandable hesitancy to install a digital machine which within one complex mechanism serves both of these functions.

On the other hand, the complete separation of digital computers and analog control systems would waste a considerable part of the potential of the digital equipment to improve power plant performance. It therefore appears likely that a certain number of computer outputs will be connected to analog control systems and may be so interconnected that a digital equipment failure would result in little more than the loss of the expected improvement resulting from the computer trimming of the analog equipment.

ONE OF THE articles in the Jan, 1960, issue of POWER ENGINEERING presented a most desirable objective: a control system for a power generating unit well integrated and based on the premise that all manipulated variables on the unit will be primarily responsive to a signal indicating the desired unit output. The article makes a strong point that all controller feedbacks shall be the proper physical measure variables rather than the positions of drive units and infers that the results can be confidently expected to far surpass any currently available control systems.

The example, used by the author, of a feedwater control states that such controls are still based on drum level with modifying signals from steam flow and feedwater flow. This is perhaps somewhat of a misconception since such controllers are usually adjusted to supply feedwater to the boiler directly in proportion to the unit output, as accurately as practical measurements permit, with the drum level doing only the residual amount of trimming necessary to compensate for the inadequacy of measurements.

Combustion controls, superheat and reheat temperature controls, and feedwater controls on many present-day systems are primarily responsive to the most practical and convenient indication of unit output, such as main turbine steam flow, first stage turbine pressure, or generator kilowatt output.

For some years, it has been the objective of most

Must Develop Gradually

By CHARLES H. SMOOT
Director of Engineering and Research
Republic Flow Meters Co Div
of Rockwell Mfg Co

superheat and reheat control systems to initiate corrective action as a predictable function of load to minimize all forecastable deviations from desired conditions and to allow the closed loop measuring control to complete the job of trimming out only those disturbances which are unpredictable and occur due to numerous effects at present considered uncontrollable.

It would perhaps be more fair to the present state of the art to say that the most stringent limitations on system performance are imposed because of the difficulty and inaccuracies in many of the physical measurements rather than a misconception of the desired end result. The article is also critical of some of the current lashups using a mixture of pneumatic, electric and perhaps hydraulic mechanisms, which are usually more a product of transient expediency than long range intent.

IT WILL PROBABLY be observed that many of the features offered as desirable and inferred as fundamentally new and unique to digital computers are, in fact, well established in the analog control systems of the present and recent past. This is perhaps just another indication that many of the digital computer proponents have not had an opportunity to become familiar with the present state of the art of analog combustion control.

Digital computers and mathematicians encounter similar problems in the performance of their work. In both cases, the most difficult part of problem solving seems to be the process of stating the problem in the language to be employed in its solution. Mathematicians sometimes feel divorced from reality when they are employed in commercial engineering businesses because most of the existing problems need a translation into a new language before the mathematician can comprehend and begin to operate on the problem.

In the same way, the digital computer, regardless of its excellence, cannot work on the solution of a plant operating problem until the observable facts of nature such as pressures, flows, temperatures, and the like have been translated into an electrical language intelligible to the digital machine.

This translation into some form of standardized language has always been a problem with analog control and instrumentation and is still a problem in both analog and digital fields. It is an area into which instrument manufacturers have and will continue to put much time and money in a continuing effort to provide better transducing devices.

The inevitable improvements in these mechanisms will probably prove to be of almost equal benefit to the analog and digital techniques which depend upon them.

It is unquestionably true that the present state of control of central stations grew somewhat like topsy, and any new over-all effort, started from scratch, can ignore the burden of past history; but sometimes this can be accomplished only at the penalty of losing the practical wisdom gained from past mistakes. The electrical utility industry is extremely cautious about pioneering into completely new fields, since the operating reliability of a plant producing electrical power must greatly exceed the reliability of plants which produce a product capable of being stored.

Since electrical energy cannot be stored practically, the customer's need and the plant capability must be instantaneously compatible, and any plant failure produces an immediate deterioration of the potential for serving the customer. This underlying restriction usually lengthens the probationary period of both new concepts and new equipment.

One of the brighter spots on the digital horizon is the flexibility of its programming memory. This flexibility will enable the production of more nearly standardized systems since such devices can serve without physical change a relatively wide spread of application requirements. It also serves as a source of considerable comfort to engineers who are frequently faced with the problems of second guessing after the systems have been put in trial operation.

OVER-ALL JUSTIFICATION and motive for the enthusiastic adoption of digital computers in power plants must, of course, ultimately rest on the economic results.

At present, the digital equipment is economically favored. Its novelty and promise of not yet adequately described benefits influences the purchaser to be less than normally critical of costs. This provides a welcome, though transient, period of accelerated development of computer applications and product improvement of other hardware necessary to make it function properly.

If the digital equipment is applied to only those things which are done more economically or better digitally than by other means and if the application of this digital equipment receives sufficient attention from people with adequate experience in the operating problems of power plants and their control systems, then the digital manufacturers and users can confidently expect to find an expanding market of useful applications with a minimum number of disappointments and delays along the path toward a more completely and economically automated power plant.

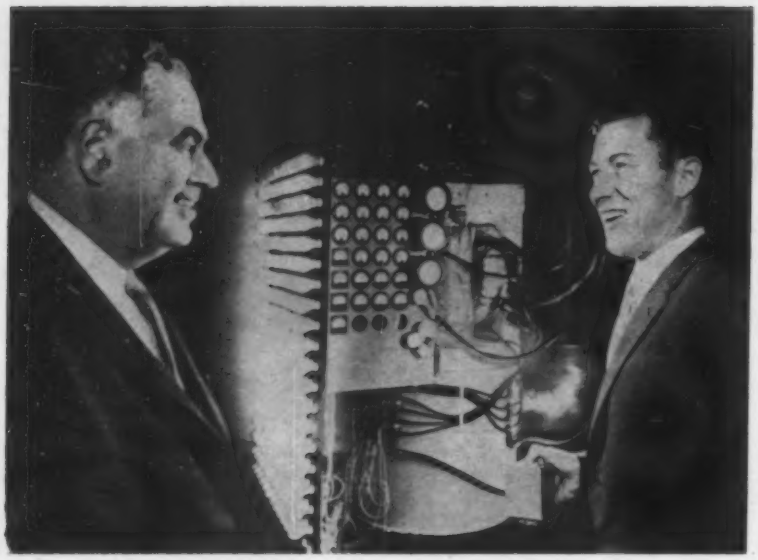


Fig. 1. Avco MHD pioneers, Dr. Arthur Kantrowitz, left, and Dr. Richard Rosa, senior scientist in charge of test program, photographed by light from 228 brightly-burning 50-watt bulbs powered by MHD generator. Equipment behind lamps is complete generator

A Power Engineer Looks at MagnetoHydroDynamics

Now in operation, 10-kw experimental MHD plant generates electricity directly from heat by passing hot gases through magnetic field, without using conventional generator. This new concept offers real chance of boosting thermal power generation efficiency to 55 or even 60 per cent

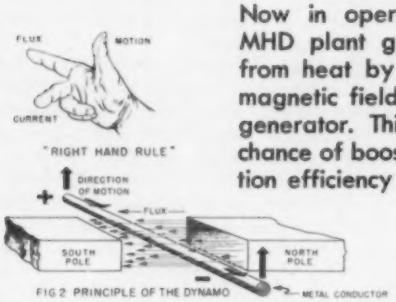


FIG 2 PRINCIPLE OF THE DYNAMO

By JOHN I. YELLOTT *

EIGHT SYLLABLES in one word — and Greek syllables at that — add up to an exciting new concept in the century-old search for more efficient means of converting heat into electric power. So new that the only textbooks on the subject were published as recently as 1957 (see references at end), MagnetoHydroDynamics has been defined as "the study of the motion of an electrically conducting fluid in the presence of a magnetic field." Abbreviated to its initials, MHD is important to power engineers for the simple reason that it offers a real chance of boosting the efficiency of thermal power generation from today's plateau of 40 per cent to a sensational 55 per cent.

The history of power generation is a record of continuous improvement in efficiency, brought about by the gradual process of raising pressures and temperatures and making logical modifications in the basic Rankine cycle. Power engineers have pushed throttle pressure up to 5500 psi, raised turbine temperature to 1200 F with two reheats, and used as many as nine stages of feedwater heating. Today's most advanced plant, Philadelphia Electric's Eddystone Station, will probably be the first to break the Btu barrier and exceed 40 per cent in plant thermal efficiency. Figure 4, which compares thermal efficiencies for the best and the average plants since Pearl Street began operation in 1882, shows that the rate of improvement in the best stations has slowed down as the designer finds himself hemmed in by material limitations on one side and by increasing first costs on the other.

Most rapid improvement occurred between World Wars I and II, when steam conditions were raised from about 250 psi, 600 F (following introduction of superheat) to 1200 psi, and up to 1000 F, and regenerative feedwater heating became universal. In this period, also, we saw the development of pulverized coal, water walls, combustion control, welded construction, topping units. Then came hydrogen cooling, chrome-moly steels, outdoor units, demineralizing, unit construction, more reheat, centralized control, pressurized furnaces, once-through boilers, very large units.

Pressure Increases

Pressures increased to 1800, then to 2500, finally to 4500 psi, and temperatures to 1150 F. Rapid improvement in the past decade was due to increased pressure, use of reheat, additional stages of feedwater heating. Results: heat rate went down from about 20,000 Btu per kwh in 1917 to about 9100 in 1957.

Today, the conservative steam station designer can look forward to one more major leap forward, when he adds a gas turbine and a pressurized boiler to his most economical steam cycle and lands at a heat rate well below the 8000 Btu per kwh, which is just out of the reach of today's best station. To go much beyond that figure, and at the same time keep station cost at a reasonable figure, we must turn to new cycles and new processes.

Spurred on by the need to learn how to supply power to satellites in outer space, scientists have been making careful studies of processes both old and new by which thermal and radiant energy can be converted directly into electricity. Some success has been attained with silicon cells, which turn sunlight into electricity, and with thermionic devices in which electrons are "boiled" out of a hot cathode and captured on a cooler anode. Thermoelectric generators, using the latest products of solid state physicists, have been improved five-fold from the 3 per cent conversion efficiency which Seeback reached in 1882. Thermocouple-type devices, however, have a theoretical efficiency ceiling at about 36 per cent, and the laboratories have much more work to do before that figure will be reached.

Today scientists have gone back into history again, this time to the

* Consulting Engineer, John Yellott Engineering Associates, Inc

work of Michael Faraday, who found experimentally in 1831 that an electric current was "induced" in a conductor that was moved across a magnetic field. When asked by England's Chancellor of the Exchequer, Gladstone, what good could come from his discovery of electromagnetic induction, Faraday replied, "Why, sir, presently you will be able to tax it." Metallic conductors were used by engineers who put Faraday's discovery to work in the great generators that are today's primary source of electric power; but, in principle, ionized gases can do the conducting, too. That is exactly what happens in MHD.

What Is MHD?

MHD is a by-product of the space age, for its fundamentals were learned during a study of the problems associated with missile nose cones in their flight through "plasma," ionized gases so hot that some of their electrons had been knocked loose from their atomic shells. The temperatures were high, well above 4000 F, but lower by ten thousand times than the fantastic levels encountered in nuclear fusion. Working first in the laboratories of Cornell University and then at the Everett Laboratory of the Avco Corp, Dr. Arthur Kantrowitz and his colleagues found that the passage of a stream of ionized gas through a strong magnetic field did indeed result in the flow of electricity across the field. Today's definition of MagnetoHydroDynamics, then, is the study of the interactions between a magnetic field and a stream of ionized gas.

The theory of electromagnetic induction has been developed in great detail since Faraday in England and Henry in the United States first observed it more than a century ago. It was a Russian, Lenz, who formulated the laws which enable us to predict what will happen when a conductor, either solid or fluid, is moved across a magnetic field. Quantitatively, those laws are too complex to be treated in a brief survey such as this, but, qualitatively, we can still follow the "Right-Hand Rule," which is learned by every engineering student when he first encounters the principle of the dynamo. In a simple case such as that shown in the sketch beside the subtitle, when the forefinger of the outstretched right hand points in the direction of the magnetic flux (towards the south pole) and the thumb is turned to agree with the direction in which the conductor is moving, then the other fingers point naturally in the direction towards which the induced current must flow.

If the simple copper rod is replaced with a high-velocity stream of ionized gas, and the magnetic field is sufficiently intense, as in Fig. 2, a current will also flow from a cathode on the far side of the duct to an anode on the near side. This current will be proportional to many factors, chief among them being the strength of the field (from 40,000 to 20,000 gauss) and the velocity and conductivity of the gas. Well within the reach of today's technology is a combination capable of producing direct current at a potential of 2500 volts and a power of 380,000 kw, at an over-all efficiency of 55 per cent!

That the phenomenon predicted by electromagnetic theory can actually take place in the manner shown in Fig. 2 was first demonstrated on a significant scale in April of 1959 at the Avco-Everett Laboratory in an apparatus constructed by Dr. R. J. Rosa. By May, the initial 1-kw output had been raised five-fold, and by August the device was producing more than 10 kw, as shown by the 228 brightly-burning 50-watt bulbs that are illuminating Dr. Kantrowitz and Dr. Rosa in Fig. 1.

From Idea to Engineering

First among the nation's power generating public utilities to recognize the potential value of MHD was the American Electric Power Corp. Under the dynamic leadership of Dr. Philip Sporn, this company has pioneered in many of the advances that have raised the efficiency of America's power plants to their present high level. Convinced that coal must carry the burden of power generation in the United States for the foreseeable future, Dr. Sporn saw in Avco's miniature MHD generator some highly intriguing possibilities.

Despite the formidable obstacles that lie between the concept of a coal-burning MHD system and its reduction to practice, the goal of 55 per cent thermal efficiency at a cost per kilowatt no greater than today's figure is so alluring that ten leading power companies have joined with Avco Corp in a solidly-financed research project. The objectives of the program are to determine the practicability and expected performance of: 1, a 450,000-kw open-cycle coal burning MHD plant; and 2, a closed-cycle nuclear-fueled MHD plant of

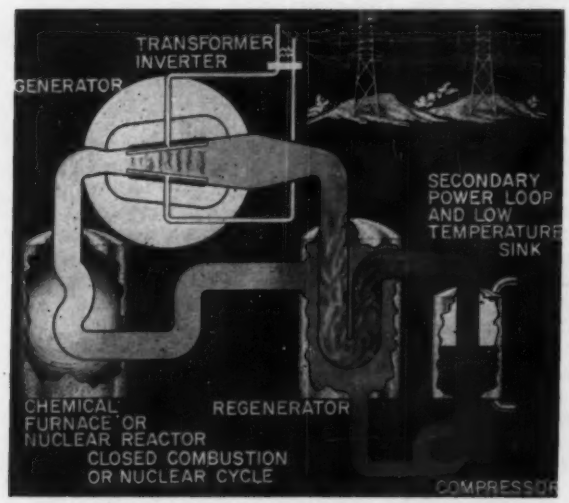


Fig. 3. Diagram by Avco showing the principle of the MagnetoHydroDynamic generator. It generates electricity by passage of very hot ionized gases through magnetic field

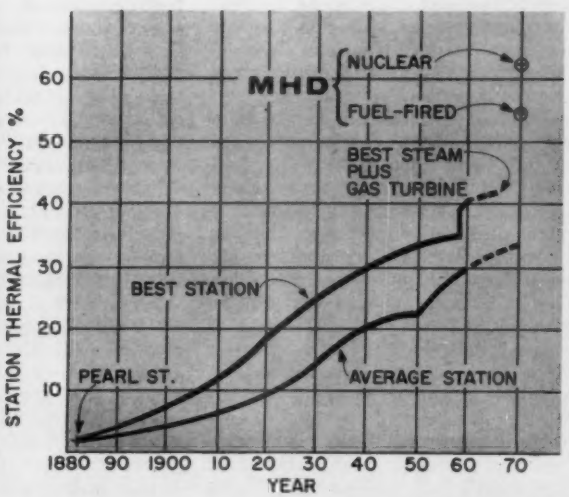


Fig. 4. Improvement in power station thermal efficiency since 1880. Lower line shows average, upper line shows year's best station. MHD could raise best stations to 55 per cent

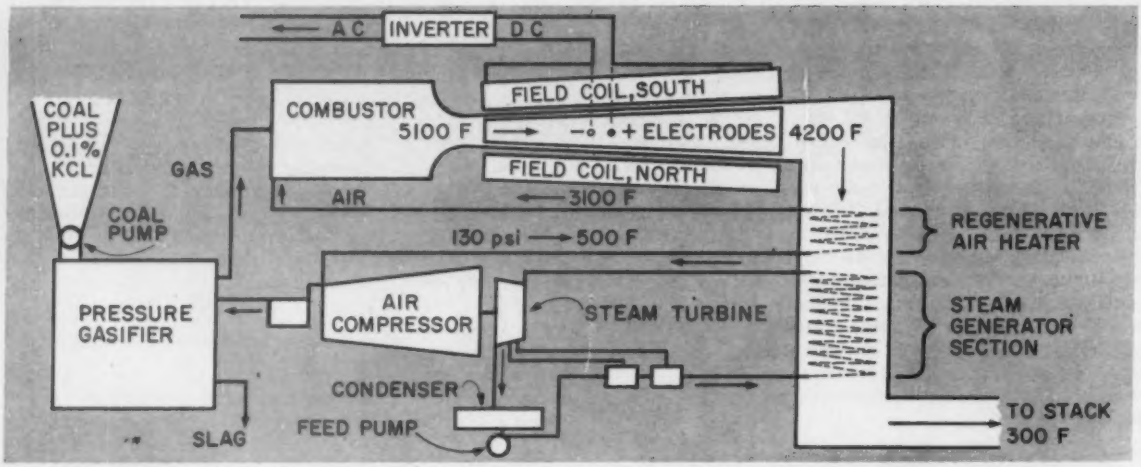


Fig. 5. Schematic diagram of possible coal-burning MHD power station. Coal is completely gasified and ash removed before burning in ultra-high-temperature combustion chamber. Air from compressor is preheated in regenerator and then raised to ionizing temperature in combustor. Predicted heat rate: 6200 Btu per kwh, 55 per cent thermal efficiency

the same capacity — *i.e.*, 450,000 kw.

The utility group joining with Avco includes: Appalachian Power Co; Central Illinois Light Co; The Dayton Power and Light Co; Illinois Power Co; Indiana & Michigan Electric Co; Indianapolis Power and Light Co; Kansas City Power & Light Co; Louisville Gas and Electric Co; Ohio Power Co; and Union Electric Co. (Appalachian, Indiana & Michigan, and Ohio Power are subsidiary companies of American Electric Power Co.) American Electric Power Service Corp will act as agent for the group in carrying out the joint research project with Avco.

MHD Hardware

To make an MHD generator operate, a continuous source of high-velocity ionized gas must be directed through a channel, as in Fig. 3, across which a strong magnetic field is maintained. Also, for connection to any existing power system, the 2500-volt direct current that comes from the MHD electrodes must be inverted to 60-cycle alternating current of the proper wave form. Even in outputs as great as 450,000 kw, the latter problem is apparently capable of solution today with mercury arc inverters at an efficiency of 96 per cent. Obviously, if a system can be involved that can produce alternating current directly, the entire project becomes more attractive, but no simple solution has yet been suggested.

The production of the high-velocity ionized gas stream can be accomplished through modifications of well-known gas turbine techniques. The Avco-AEP Co proposals envision a combined cycle, along the lines shown diagrammatically in Fig. 5, in which a gigantic air compressor, driven by a steam turbine, supplies some 2,500,000 lb of air (567,000 cfm!) at 140 psia, 550 F. A regenerative air heater boosts the temperature of the air to 3600 F before it enters the pressurized combustion chamber, where fuel is burned to raise the temperature to 5100 F. The ionization that naturally occurs at this temperature is assisted by "seeding" the combustor with as little as 0.1 per cent of potassium chloride.

If the fuel is natural gas, or cleaned coal gas, the combustor does not present insuperable difficulties, since the pressures are relatively low and the surfaces can be water-cooled. If coal is to be burned directly, the vaporized ash becomes a slight help, because it can contribute somewhat to the ionizing of the plasma; but it is a far more significant hindrance, because it must first condense and then solidify somewhere in the system. The MHD generator itself, essentially a rectangular diverging nozzle some 60 ft long, expanding from 3 ft in diameter at the throat to 6 ft at the outlet, is also well within the scope of today's techniques, since the heat transfer rates would be similar to those encountered in today's cyclone furnaces. The electrodes, which are necessarily exposed to the full fury of the supersonic plasma, will be the most critical components, because the cathode must be a good electron emitter, while the anode must be a reasonably good conductor of electricity. Field current comes directly from the MHD busbars.

The regenerative air heater must add more than 3000 F to the temperature of the incoming compressed air, while it cools the plasma from 4200 F, at which it leaves the MHD generator, to approximately 1600 F, at which it enters the unfired steam generator. In cooling the outgoing gases to 300 F, the waste heat boiler reclaims the energy needed to drive the air compressor and to provide 10,000 kw in auxiliary power.

The regenerative air heater poses the most difficult problems to the MHD system designer because the air on the "cool" side would be highly oxidizing, while the plasma temperature at the inlet would be far too high to permit the use of any known metal. Pebble heaters look like the most logical way to attack this key problem, with zirconium oxide as a likely material because of its stability even under such demanding conditions.

Heat Rate and What It Will Cost

In a heat balance prepared jointly by American Electric Power Service Corp and Avco, a coal input of 206,000 lb per hr is expected to provide a net output of 462,000 kw, giving an anticipated heat rate of 6200 Btu per kwh. A thermal efficiency of 55 per cent appears to be well within the range of possibility, yielding a fuel-plus-seeding cost of 1.78 mills per kwh, fully 16 per cent better than today's best.

The first cost estimates prepared by the Avco-AEPS Co team lead to an investment cost of $92 per kwh for today's steam plant, as compared with about $94 for the MHD plant, of which $33 is required for the dc-ac inversion. The goal of the MHD project is clear — a major gain in efficiency with a very minor penalty in investment. The opposition that

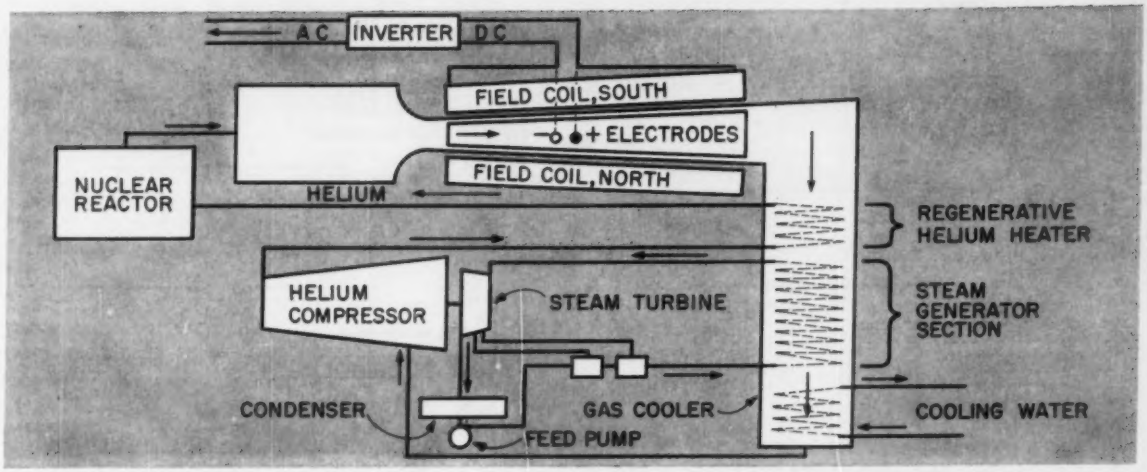


Fig. 6. Proposed MHD plant, using nuclear reactor as a heat source in closed cycle. Steam turbine supplies compressor power, as before, but in this case, instead of air, the working medium is helium seeded with cesium—a "plasma." Nuclear reactor and regenerator heat it to 4100 F. Leaving generator plasma heats helium, generates turbine steam

nature will put up is equally clear: Can an ionized stream containing vaporized ash be created and kept under control as it rushes through the MHD generator and the all-important heat exchanger?

Prospects of combining MHD with an atomic reactor to obtain, for the first time, really good thermal efficiency, appear to be encouraging. Once again, gas turbine technology would be coupled with an MHD power generator, but an inert gas such as helium would be used in a closed cycle, with 1 per cent of cesium added to enable adequate ionization to be accomplished at a top temperature of only 4100 F. Reactor techniques have not yet reached the point where temperatures of this level can be maintained, but there is good reason to believe that, with helium or argon as the working fluid, the job can be done.

Nuclear—MHD Cycle

The cycle envisioned is shown, in simplified form, in Fig. 6. A helium stream seeded with cesium will be compressed, then heated in a regenerator to 2500 F. The nuclear reactor will add the next 1600 deg and discharge the ionized helium into the MHD generator at 4100 F. In passing through the MHD generator, a net output of 490,000 kw would be realized. The essential dc-ac inverter would dissipate another 20,000 kw, and 470,000 kw would be available at the busbars.

The plasma, having done its job of power generation, would enter the high-temperature side of the regenerator and give up some of its heat to the compressed helium. The remaining heat would be used to generate steam for driving the compressor, and only a minor portion would have to be thrown away in the cooling water. It appears that a heat rate as low as 5800 Btu per kwh is attainable, corresponding to a station efficiency of nearly 59 per cent.

Chances for Success?

New knowledge of the behavior of gases at temperatures that are high, but still attainable by today's standards, has led to the building of experimental apparatus from which has come a significant amount of electricity without the use of a conventional electric generator. Extrapolation of these experiments leads on to the hope that the MagnetoHydroDynamic principle can be successfully applied to the building of generator-less power stations in which the working fluid will be an ionized gas. Its pressure will be moderate but its temperature will be so high that rotating equipment could not possibly be built to contain and extract power from it. Thanks to the fact that the temperature level is so high, thermal efficiencies far above today's best accomplishments can be anticipated for both fuel-burning and nuclear plants.

The obstacles are admittedly formidable, because heat exchangers must be devised that can work in a temperature range far above that of the furnaces we use now. If coal is to be used as the fuel, as eventually it must, means must be found to eliminate the ash at some stage in the process where it will do the least harm. If nuclear energy is to be used as the heat source, a reactor must be devised to operate safely with a gas outlet temperature above 4000 F.

The objective of the work now under way, financed by ten farsighted utility systems and the Avco Corp, is to raise the efficiency of thermal power generation from today's 39 per cent plateau to the mid-50's. If the MagnetoHydroDynamic principle can be extended directly to the generation of 60-cycle ac, it is even possible that we may see 60 per cent efficiency in the 60's, in a plant which costs even less than today's conventional steam station.

The goals of the undertaking are 450-megawatt stations for both fossil and nuclear fuels! The chances of success? Good enough to justify a half-million dollar investment of private capital! THE END

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Author's Note: There is no simple treatment of MHD available in today's textbooks, since it is inherently a very complex subject. References 1 and 2 represent the only books on the subject. The literature references are principally technical papers reporting the work of Dr. Kantrowitz and his colleagues at Cornell University.

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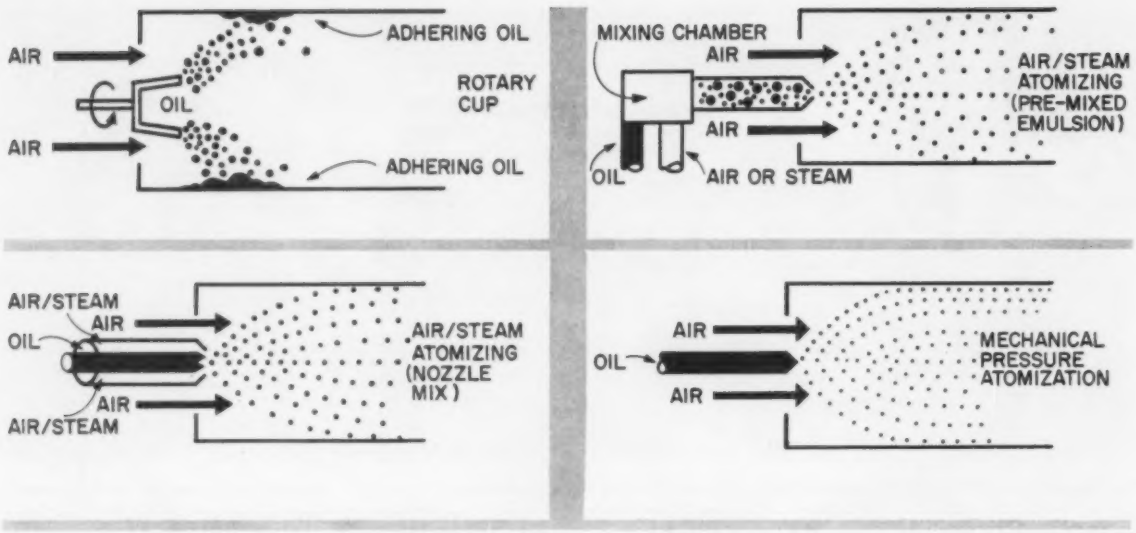

What Oil Burning System for the Automatic Package Boiler?

Package boilers do not offer a favorable firing condition for many types of burners. But four types can be considered as basic. This article describes each of these, including advantages and limitations

By PATRICK D. GOGGIN *

INCREASING POPULARITY of automatic firetube boilers of the Scotch Marine type with the submerged furnace tube, designed for maximum radiant heat absorption, focuses attention on burner systems. Accomplishment of satisfactory combustion within the confined diameter and elongated furnace of the "package" boiler combustion tube presents numerous complicating but not insurmountable firing problems.

Any type of burner performs reasonably well on conventional boilers with large firebox volumes. Deficiencies in flame pattern are not a serious handicap. In large furnaces with extensive refractory lining and checkerboarding of the furnace floor, combustion can be completed efficiently without extensive carbon deposits. Flue gas velocities are low. Combustion volume is large. Package boilers, however, do not offer a favorable firing condition for many types of burners.

A brief checklist of the requirements of an oil burner for modern package firetube boiler designs is helpful in recognizing the problem and determining the best possible solution. In general, any efficient oil burner must:

1. Thoroughly atomize oil of all commercially available grades without drooling, fouling, or clogging. This requirement has become increasingly important as better cracking of poorer crudes has left a higher proportion of solids in the heavier residual oils.

2. Maintain a uniform atomization characteristic over a comparatively wide capacity range. This is necessary to secure efficiency of modulating firing equipment expected to operate over high turndown ratios.

3. Provide a perfect mixture and satisfactory pattern of atomized oil and incoming combusion air to assure rapid and complete combustion within the confines of the furnace over the entire range of firing rates. This means low-fire rates approaching 20 per cent of capacity with high efficiency and complete cleanliness.

4. Operate without impingement of unburned oil upon cold furnace walls.

5. Burner must be simple to clean and maintain from both user maintenance and professional service points of view. Currently in use in all types of industrial, commercial, and institutional applications, package boilers must be equipped with rugged non-critical burners avoiding complex laboratory-type components requiring constant supervision, adjustment, and skilled care.

To satisfy these essential design requirements, four basic oil burner types are available for consideration and application to automatic package firetube boilers: rotary cup; air atomizing; steam atomizing; mechanical atomizing.

Rotary Cup Burners

In rotary cup burners, atomization is accomplished by spinning a film of oil off the lip of a high-speed cup rotating at 4000 to 5000 rpm. This results in a projection of relatively large globules of oil into the combustion chamber. In order to shape the flame as well as accomplish further atomization of the oil, it is necessary to introduce a blast of high velocity secondary air out past the air nozzle of the burner to further break up the globules of oil and so permit ignition and combustion. Frequently additional incandescent furnace refractory lining is required as an aid to combustion.

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◀ In the rotary cup burner, oil flows through rotating axle and is broken up into combustible droplets. Atomizing medium (air or steam) can be premixed with the oil and injected as an emulsion into combustion chamber; or the mixing can occur when oil and atomizing medium enter the chamber. In mechanical pressure atomization, sudden release of pressure as oil is injected into chamber breaks it into combustible mist

Rotary cup burners have many mechanical parts that must be set accurately to obtain satisfactory operating conditions. Frequent breaking away of the coke which tends to form on the combustion walls is necessary when the burner is not properly adjusted. Such adjustment on a rotary cup type of burner is quite sensitive, particularly with viscosity or temperature changes.

Since the rotating cup is dependent somewhat upon the blast of secondary air for final atomization, it is difficult to accomplish extensive modulation without serious loss of efficiency in the automatic package boiler. Some designs have a tendency to drip oil from the cup after the burner is shut off, particularly with a new supply of oil at slightly different viscosity or when preheat temperature is not maintained at a close level for which the burner has been adjusted.

Rotary cup burners are relatively inexpensive. They are built by many manufacturers and are easily and readily available in normal trade channels.

Air Atomizing Burners

In central station practice, air atomizing burners have not been too widely used, presumably due to the necessity for a constant and dependable compressed air source. On boilers of the automatic, package firetube design, integral compressors have been built into the burner systems to supply air at 15 to 40 psi pressures for emulsifying the oil.

Performance of all types of oil burners is greatly influenced by the manner in which combustion-supporting air is supplied to the atomized fuel to secure thorough mixing. Naturally, the use of air as the atomizing medium has an advantage in this direction. In some designs the air and oil are admitted through small perforations directly at the nozzle tip in a nozzle-mix procedure. In others, the air and oil are mixed well back of the combustion furnace and the emulsion injected into the furnace in a modified mechanical pressure atomizing burner design.

Flame pattern from the various air atomizing burner designs is generally more satisfactory for the integral furnace of the Scotch Marine type of boiler than is the flame pattern of the rotary cup burner.

Perhaps the major drawback to use of air atomizing types of burners is their vital dependence on their air compressor. The high speed of the air compressor to develop the necessary head, like the high speed of the spinning cup on the rotary cup burner, presents a constant source of maintenance. In constant operations, such as industrial loads, the air compressor tends to overheat and fail, shutting down the boiler with consequent costly lost production time. In intermittent operation, lubrication tends to drip out, with the resultant extra wear during each boiler start-up.

Located relatively inaccessibly, air compressor maintenance poses perhaps the major problem to air atomizing burner operation.

Steam Atomizing Burners

Steam atomizing burners are relatively simple, and several different designs are extremely popular for central station service. Steam and oil may be mixed in an internal plenum arrangement before entering the furnace, or steam flow through the nozzle may be used to entrain the fuel oil for combustion in several different external mixing designs. The flame shape is easily controlled. Commercially available steam atomizing burners have been developed into highly efficient units over a wide range of firing rates.

Tests show such burners quite applicable to the package units under discussion. However, a continuous supply of steam is required which necessitates the use of supplemental starting equipment until atomizing steam is produced by the boiler itself.

Some preliminary work, conducted by both users and manufacturers, utilizing boiler steam on basically air atomizing burners after start-up, has been largely experimental. In some cases the research was forced by repeated air compressor maintenance problems. In some cases the experiments were conducted frankly to find a better burner than the air atomizing burner.

In using steam and air interchangeably through the nozzle of an air atomizing burner, steam consumption can approach 10 per cent of the boiler full load capacity, which is uneconomic. Exclusively steam atomizing nozzles could be developed using only 1 per cent to 3 per cent of the boiler load, but air compressors, required for start-up, are not available to develop sufficient head to force sufficient air through the orifices required to restrict steam flow.

Steam atomizing is not at all practicable on institutional and commercial heating loads and other intermittent service. Higher pressure steam than that available from heating boilers is required for atomization.

Mechanical Pressure Burners

Mechanical pressure atomizing burners have been developed to a relatively high degree of perfection for many types of service, from domestic heating plant to shipboard service. Both ultimate types of applications demonstrate the high degree of dependability found in the basic mechanical atomizing burner.

In central station applications with multiple burners, individual fixed firing rate burners are cut in and out with load changes. Flexibility of nozzle design permits accurate control of flame patterns to suit any furnace characteristic. Flow capacity and angle of spray can be selected to meet any requirement.

Contrasting with fixed capacity central station mechanical pressure atomizing burners, are the wide range pressure atomizing burners (Navy type), which are practically standard for marine service. Burning the heaviest Bunker C No. 6 oils and operating at pressures up to 300 psi, they stand up admirably under the most punishing service demands. Such burners utilize a compound atomizing orifice at the nozzle tip.

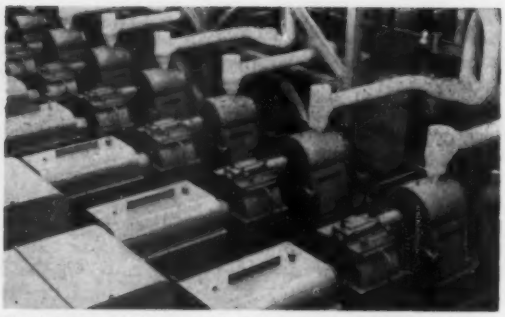
Reduced ratings are obtained by varying the amount of oil returned to the pump suction or storage from between the first orifice and that leading to the combustion chamber. Such burners have an excellent turndown ratio of 20:1 — 5 per cent of full firing rate.

From the point of view of the restrictions imposed by the narrow confines of the submerged combustion tube of the automatic package boiler, the modern modulating mechanical pressure atomizing burner is completely adaptable. The flame pattern is readily controlled with minimum excess air.

Costs of pumping oil at high pressure required for atomization compare very favorably with the much higher costs of motor operation for the rotating cup of the rotary burner, of compressor operation for the air atomizing burner, and of generated steam for steam atomization.

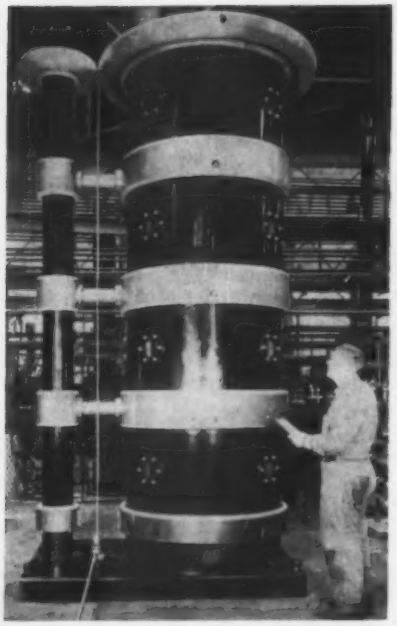
Perhaps the greatest single virtue of the pressure atomizing burner for automatic package boilers is its simplicity of construction and ease of maintenance. THE END

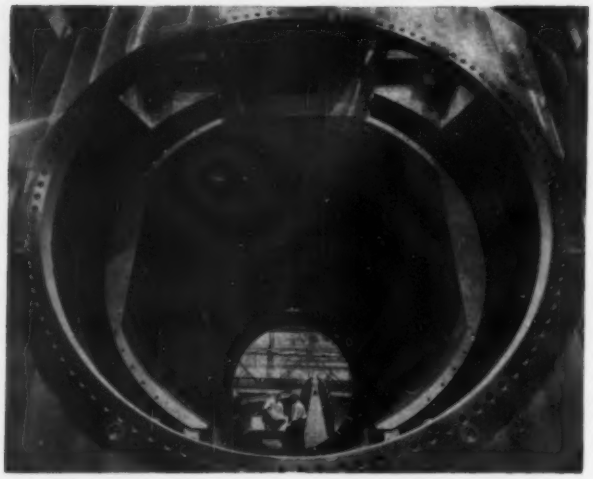
60-ton heat exchanger, 40 ft long and 13 ft wide, goes into Consolidated Edison's Indian Point nuclear electric generating station on the Hudson River near New York City. Unit is one of four being built by Babcock & Wilcox for the 275,000-kw station

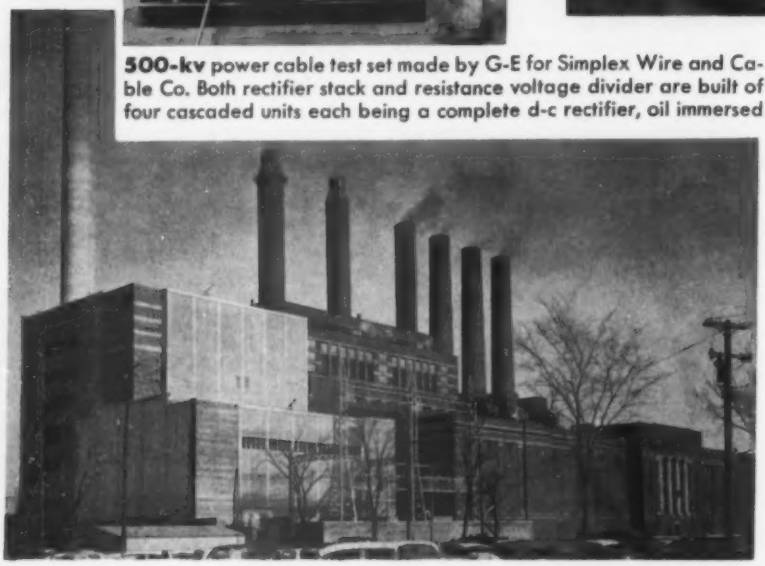


7 high speed boiler feed pumps installed at Public Service Electric & Gas Co's Linden, N. J., generating station. These Worthington units are typical of the new, more compact stiff shaft designs being used today

POWER ENGINEERING'S NEWS REEL





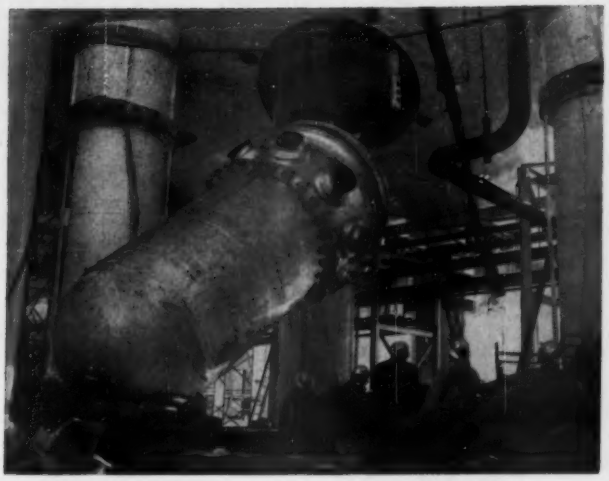


500-kv power cable test set made by G-E for Simplex Wire and Cable Co. Both rectifier stack and resistance voltage divider are built of four cascaded units each being a complete d-c rectifier, oil immersed

Power for Arkansas will come out of this steel frame which will house a 3600-rpm turbine generator built by Westinghouse for Arkansas Power and Light Co's new station near Helena. Rated at 384,000 kva, the completed unit is scheduled for delivery this summer. Steam turbine is a 325,000-kw unit

New addition (left) to Avon Plant of Cleveland Electric Illuminating Co houses a 250,000-kw turbine generator powered by a monotube once-through boiler which can develop 3500 psi. Avon's total generating capability is now 635,000 kw. Cost of entire project was $39,000,000. Unit is now on the line

200-ton generator core, divested of its rotor and stator frame, moves aloft down an alley to shipping bay in G-E plant. It's bound for the Port Jefferson steam plant of the Long Island Lighting Co. Part of a 156,250-kw generator, core had to be shipped separately because of width of the unit. After testing of assembled generator, frame was trisected for shipping



Reactor vessel for Yankee Atomic Electric Plant at Rowe, Mass., is lifted through shipping hatch into the sphere that envelops the plant. Vessel cost about $1,500,000, measures 27 ft long, 13 ft wide, ranges in thickness from 4 to 9½ in. of solid steel. Full operation at Yankee is set for late 1960

Wood-stave pipe was selected by Upper Peninsula Power Co (Mich.) for 6050-ft-long line which delivers water from Victoria Falls dam to hydro station. Material is kiln-dried, pressure-creosoted Douglas fir supplied by Simpson Engineered Wood Products Co, has life expectancy of 50 years. Staves are made 3½ in. thick, 5½ in. wide

38 miles of brass tubing—127,000 lb—go into a big new steam condenser for a central power station at Magna, Utah. This two-pass condenser has 7620 Admiralty brass tubes made by Chase Brass & Copper. Its 58,000 sq ft of cooling surface will handle 415,000 lb/hr

New Stockholm Plant Generates 80 Mw of Power and Heating For 60,000 People

Largest combined plant in Sweden has several unusual features which will be of interest to American power engineers. The condenser cooling water serves as the principal source of energy for the central heating system. Coal is stored under water, and oil storage is in solid granite cisterns

IN THE SUBURBS of Stockholm, Sweden, a very unusual combination plant is nearing completion. The fact that it generates electric power and supplies central heating steam is not the unusual feature, as this is not a new concept.

Some of the plant equipment details are unique, however, and worthy of mention. While one or two items would not appear to be too practical here in the United States, the balance are certainly interesting to us.

As to the general details of the plant, it consists of three oil-coal-fired boilers, three turbine-generators, three hot-water accumulators, and the various conventional auxiliaries to complete the plant.

Total capacity of the plant is to be

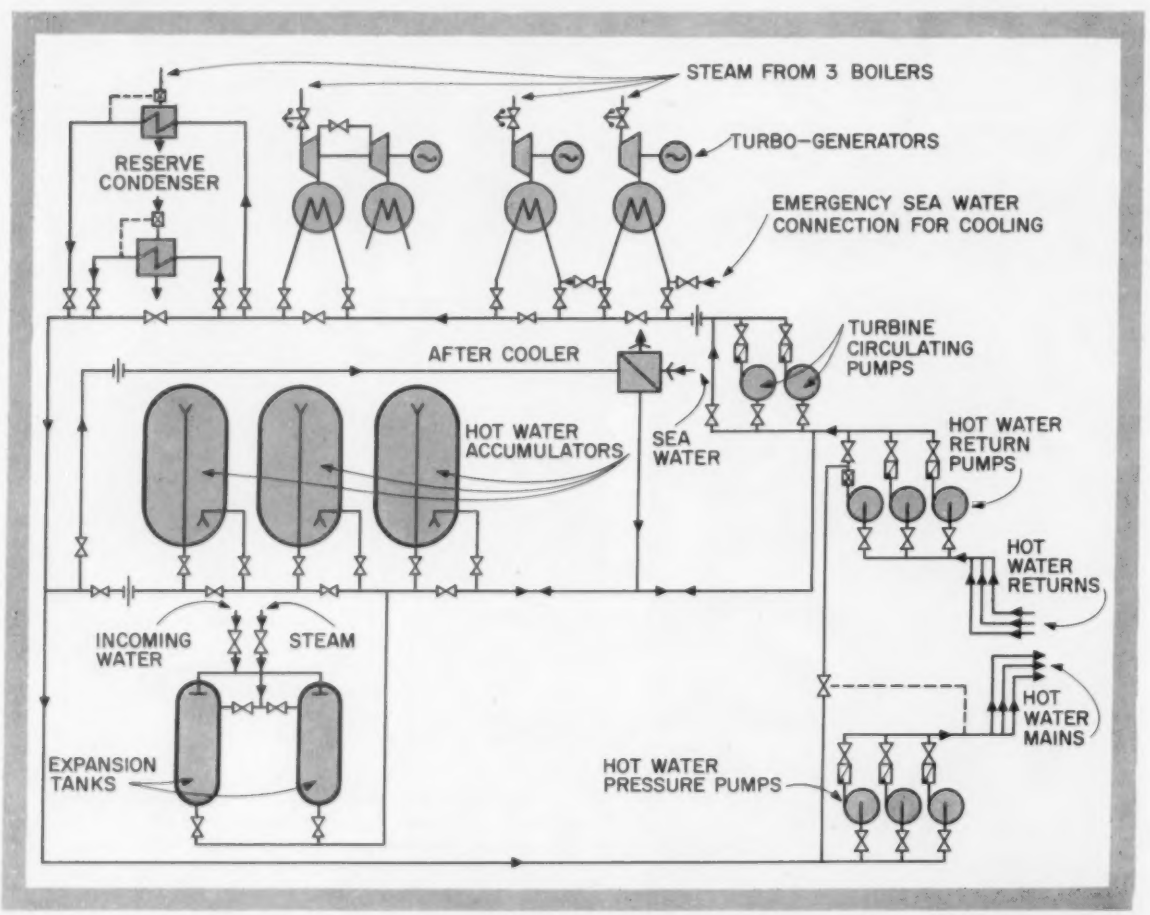


Fig 1. Diagram of the installation. Three condensers are in series, one is connected for emergency cooling with sea water

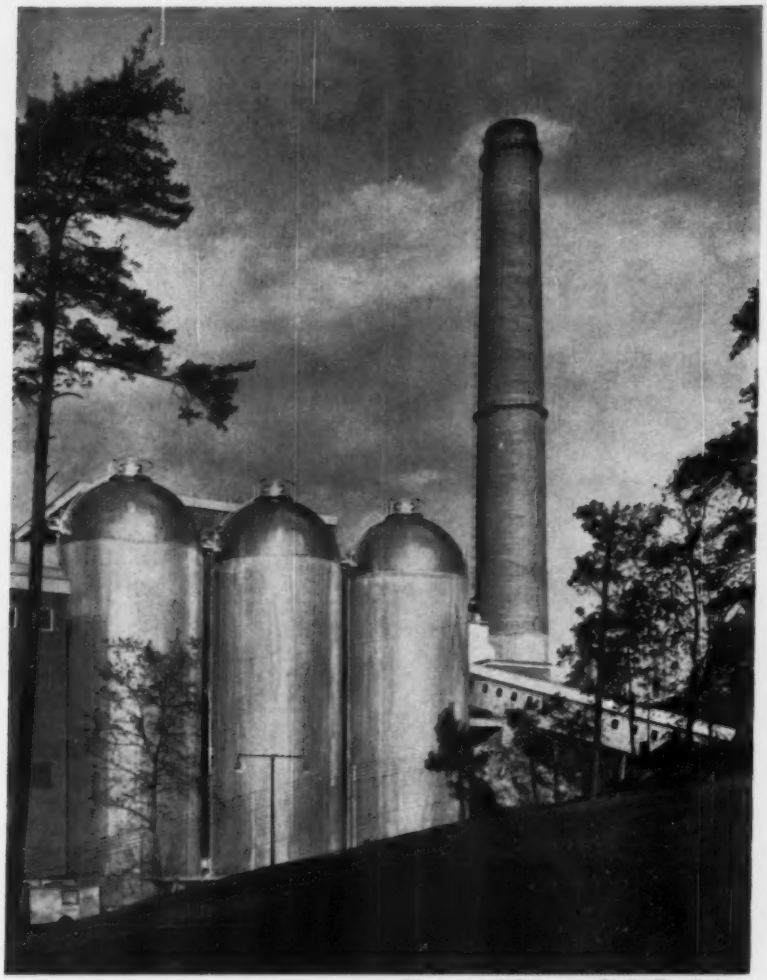


Photo courtesy SIP/American-Swedish News Exchange

Fig. 2. Hot water is stored in these 3 large accumulators outside plant building

80,000 kw of electric power, and 37.5 million Btu's per hour. Practically all of the equipment is of Swedish manufacture: Boilers by Svenska Metallverken Co, turbines by Stall, and generators by ASEA.

Coal is stored partly below sea level and partly above. The submarine storage is walled in by embankments of rock and by concrete caissons, which also constitute the docks for unloading the necessary fuel imports.

Fuel Consumption

Coal storage site is capable of holding 100,000 tons, and the oil cisterns, blasted out of the solid granite rock foundation, can hold 250,000 barrels of liquid fuel. The annual fuel consumption of this suburban power-and-heat plant is estimated at 80,000 tons of coal, or 50,000 tons of oil. This depends, however, on the demand for power and heat — which, in turn, is related to temperature and other climatic conditions.

Hot-water distribution system — when one considers the distance to be covered and the severe climate of Sweden during several winter months — is of special interest. The iron tubes are insulated by a layer of cellular concrete, and are protected by an outside layer of conventional concrete. On its way to the consumers, the heating water, which will have an initial temperature of 170 to 250 F, will in some cases traverse up to three miles. Nevertheless, it is carefully calculated that the heat loss will be no more than an average of five per cent a year.

As a curiosity it may be mentioned that the Swedish State Power Board, which is chiefly concerned with harnessing the country's hydroelectric power, will be supplied with heat from this plant for its new headquarters, reported to be the largest office building in northern Europe. It is now under construction at Racksta, about three miles from the new thermal station.

Hot water is stored in three large accumulators, outside the plant building. These are shown in Fig. 2 and are 100 feet high; they are heavily insulated, and are aluminum-clad. A 300-ft-high smokestack completes the picture of a very modern power facility.

Working pressure of the boilers is about 1100 psi, and the steam temperature is up to 970 F maximum. There are three boilers in the plant, each boiler feeding its turbine. Two of the turbines are provided with condensers suitable for heating the circulating hot water.

Hot Water Temperature

The temperature of the hot water going from the turbine condensers is dependent on the weather, and varies between about 155 F and 250 F. Thus there is sometimes a vacuum on the outlet side of the turbines; sometimes a little over-pressure. The third turbine is a condensing steam turbine, with regulated bleeding for output of steam to a hot-water condenser. This machine can provide full power, even with little demand for heat.

The other two turbines can be kept in operation, even with small demand for heat, due to there being possibilities of cooling the hot water with sea water. In addition, one of the condensers can be switched over, in emergency, and cooled with sea water directly, instead of using hot water.

Figure 1 shows a one-line diagram of the equipment installation in the plant. It can be noted that three condensers are in series; however, one of them is connected for emergency cooling with sea water. In such cases, necessary valving prevents entrance of the salt water into the hot-water heating cycle.

In addition to the three hot-water accumulators, two expansion tanks are installed, to accommodate the increase in volume as the water is heated. A source of compressed air gives the required cushion on top of the water. THE END

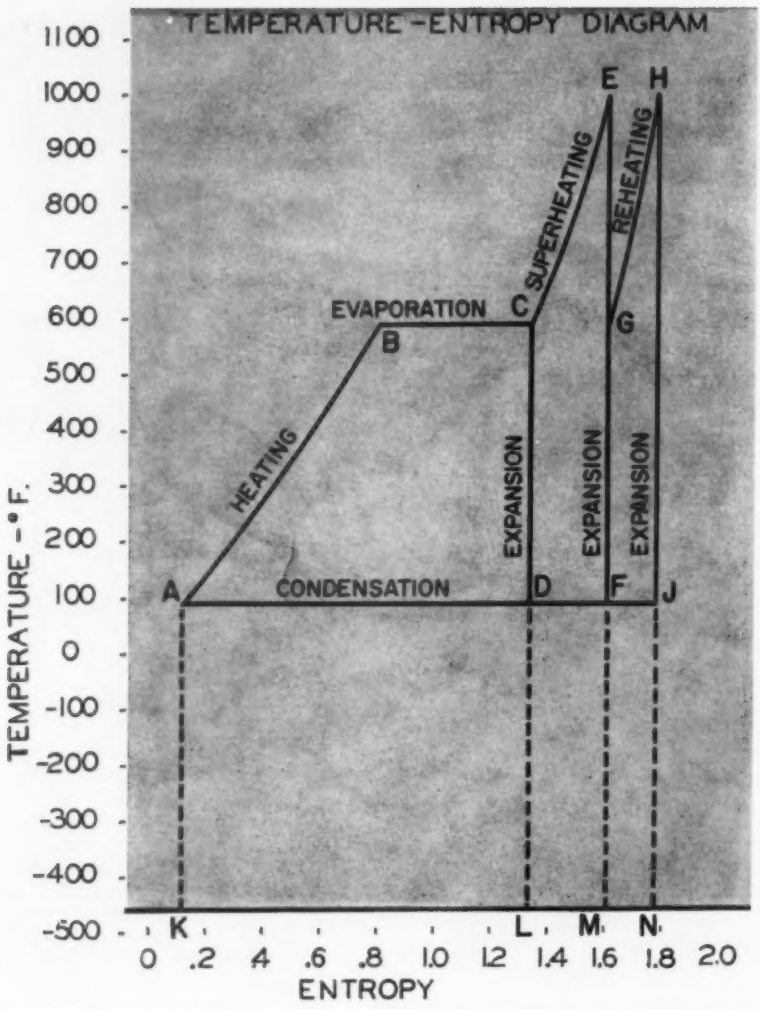


Fig. 1. Temperature-entropy diagram for water vapor showing cycle energy areas

Mr. Lemezis concludes his comprehensible review of the fundamentals of steam power cycles. Part I appeared on page 84 of the March issue

Fundamentals of Steam Power Cycles

By S. LEMEZIS *

SEVERAL IDEAL steam cycles have been drawn on the T-S diagram, Fig. 1. These can be recognized as ideal steam cycles because the expansion processes are shown as vertical lines (no increase in entropy during the process) and, therefore, represent the performance of 100 per cent efficient turbines.

Use of the diagram can be shown with the saturated steam cycle ABCDA; *i.e.*, one in which steam is supplied to the turbine with no moisture and zero superheat, or *saturated*. Total thermal energy supplied to the cycle above absolute zero level is shown by area ABCLKA, while total energy available for conversion above exhaust temperature level is shown by ABCDA. Theoretical thermal efficiency of the cycle is the ratio:

$$\frac{\text{Available Energy ABCDA}}{\text{Total Energy Supplied ABCLKA}}$$

If we choose the throttle steam pressure at 1450 psig and the exhaust pressure at 1.5 in. Hg Absolute, this theoretical thermal efficiency will be 39.25 per cent.

To consider the beneficial effect of superheating steam before expanding it in the turbine, consider the relation of area CEFDC to the total heat added, CEMLC. Theoretical efficiency of this superheating alone is 54.62 per cent for an initial temperature, E, of 1000 F. Efficiency of heat addition in the superheat portion of this diagram is greater than that of the saturated portion because the heat is now added at a higher average temperature level. Actually, the superheat cycle ABCEFA represents the theoretical cycle upon which the great majority of steam turbines in service operate today. For an initial pressure of 1450 psig and temperature of 1000 F, exhausting at 1.5 in. Hg Absolute, theoretical efficiency is 42.7 per cent.

Reheating can be added to the cycle by expanding to pressure G in the turbine, heating the steam to some elevated temperature H at constant pressure, and then expanding to the exhaust pressure. Again, the theoretical gain in cycle efficiency is shown by the ratio of the Available Energy/Total Heat added areas. Adding reheat to 1000 F to our pre-

*Design Eng'r, Medium Turbine Eng'r'g, Steam Div, Westinghouse Electric Corp

vious 1450 psig, 1000 FTT, 1.5 in. Hg Absolute cycle will raise the cycle theoretical thermal efficiency to 44.34 per cent, a gain of 3.84 per cent over the non-reheat cycle.

Changing the exhaust pressure will have the effect of moving the line ADFJ up or down, thus altering the ratio of the areas representing available and unavailable total heat energy.

Since the exhaust pressure is maintained at its usual low absolute level by condensing steam and removing air and non-condensable gases in the condenser, the level which can be attained in any plant will depend almost entirely upon the temperature and flow quantity available in condenser circulating water.

As an example, changing the exhaust pressure of our 1450 psig, 1000 F/1000 F reheat cycle from 1.5 in. Hg Absolute to 1 in. Hg Absolute will improve theoretical cycle efficiency from 44.34 per cent to 45.26 per cent. This effect is so pronounced that power stations are nearly always designed for the lowest exhaust pressure (temperature) which can be obtained using the available supply of circulating water.

In any actual cycle, expansion would not take place at 100 per cent efficiency, and there would be some pressure drops involved in superheating and reheating; therefore, there would be a greater increase in entropy during each process than indicated on the theoretical diagram, Fig. 1, and the ratio of *available energy* to the *unavailable energy* areas would be lessened.

Obviously, no real cycle could attain the efficiency levels calculated for a theoretical style, but the effects of changing steam conditions can be studied on a theoretical basis, and valid conclusions drawn as to the thermodynamic results which can be attained for different conditions.

Regenerative FW Heating

In explaining the thermodynamics of regenerative feedwater heating, it is helpful to refer to a modified T-S diagram, Fig. 2, on which entropy is considered a distributive quantity and the abscissa is then total entropy. ABCDA would represent a theoretical saturated steam cycle in which the steam flow to the condenser was exactly equal to the throttle steam flow. In order to heat feedwater from temperature A to temperature 12, steam is extracted from the turbine at pressures 1, 3, 5 and 7 and gives up its latent heat in four feed heaters which successively heat the feedwater through temperature ranges A-9, 9–10, 10–11, and 11–12.

Feedwater would enter the boiler at temperature 12; on such a plot, the available energy is represented by the area ABC12345678EA, while the unavailable energy is represented by the area AEGFA. Regenerative feed heating has reduced the unavailable energy by a greater percentage than it has reduced the available energy. In fact, a calculation of our old 1450 psig D & S, 1.5 in. Hg Absolute cycle shows that the theoretical efficiency can be raised from 39.25 to 47.85 per cent by introducing the maximum amount of feed heating possible (infinite number of heaters, feedwater heated to saturation temperature at throttle pressure). Gains attainable from regeneration are so great in proportion to the cost of attaining them that feedwater heating is used in every utility power station operating today.

Improving Cycle Efficiency

From studying theoretical steam cycles and accurately measuring their T-S diagrams, one can reach the general conclusion that the way to improve the efficiency of any given cycle is to raise the throttle pressure, throttle and reheat temperatures, number of reheats, and number of feedwater heating stages.

Careful study of the figures will show that the beneficial effect of any given increment in pressure, temperature, or number of heaters or reheats is less, the higher the level from which one starts to add these increments. In actual power plants, the design problems associated with pressures and temperatures, and the complications resulting from many reheaters or feed-heating stages, set practical economic limits to the use of these devices for improving plant efficiency. Therefore, for any turbine rating one may select, there will have been found from experience some practical limits to steam conditions and cycle complexity.

Heat Power Cycle

The heat power cycle has come a long way from the early days of the steam turbine, when plant heat rates of forty and fifty thousand Btu per kilowatt hour were representative of good practice. The lower curve in Fig. 3 marked "Carnot Cycle" shows the ultimate efficiency of a power cycle for any given initial temperature. This derives from the familiar equation:

$$\text{Efficiency} = \frac{\text{Initial Temp.} - \text{Final Temp.}}{\text{Initial Temp.}}$$

The temperatures are absolute, or Fahrenheit plus 459.4. In the Carnot Cycle, all heat is presumed to be added at a constant temperature, and waste heat is also rejected at a constant temperature. However, in any practical cycle, heat is added at varying temperature. Therefore, heat addition is an irreversible process. In the steam cycle, heat is added to the feedwater at a varying temperature, evaporation is at a constant tem-

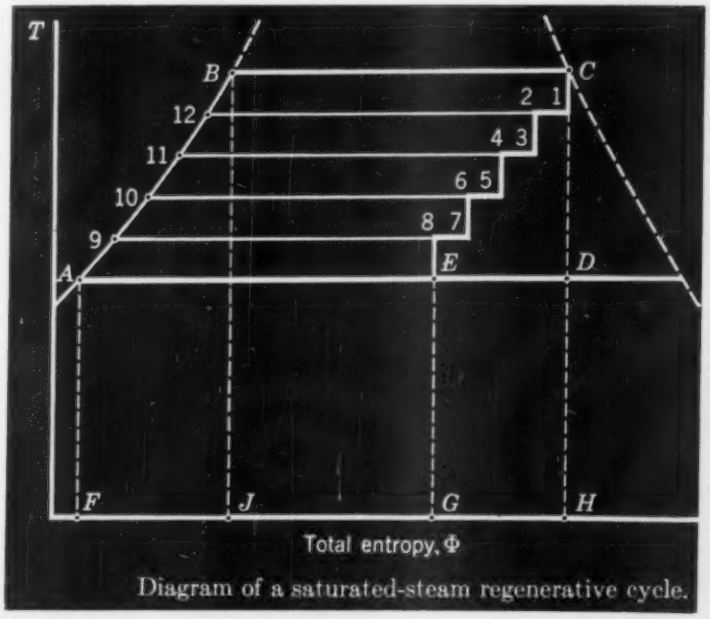


Diagram of a saturated-steam regenerative cycle.

Fig. 2 helps to explain the thermodynamics of regenerative feedwater heating

perature, and superheat and resuperheat are added at varying temperatures. Heat is rejected to the condenser at a constant temperature.

Three curves marked "Ideal Regenerative Cycle" show the difference between the irreversible regenerative steam cycle and the reversible Carnot Cycle. This establishes a new and higher limit of heat rates which can be approached but never reached. In these non-reheat, single-reheat, and double-reheat ideal regenerative cycles, there are none of the losses which occur in all practical cycles.

These cycles, then, are composed of a perfect boiler having no losses; a turbine having 100 per cent efficiency; a feed-heating system having an indefinite number of heaters heating the feedwater to the temperature corresponding to the throttle pressure; a generator having 100 per cent efficiency; and with no auxiliary power requirements for fans, pumps, and so forth. Gains with increasing temperature for the "Ideal Regenerative cycles" are greater than for the Carnot Cycle because the initial pressures have been increased with the increases in temperature.

Three curves marked "Practical Regenerative Cycles" show the record of progress made in the development of the steam cycle from 400 psig, 750 F, 1½ in. Hg Absolute in 1926 to 5000 psig, 1200 F, with two stages of reheat, each to 1050 F, and a back pressure of 1½ in. Hg Absolute in 1955. The increased slope of these curves, as compared with the ideal regenerative cycles, represents the improvement in component efficiencies.

Difference between the *practical* and *ideal* cycles represents the stack gas losses (the difference between the stack gas temperature and ambient temperature); the turbine inefficiency (blading inefficiency, leakage losses, throttling losses, exhaust losses, electrical and mechanical losses, and the like); feed-heating cycle losses, including the boiler feed pump losses; the electrical and mechanical losses; and auxiliary losses, such as fans, pumps, and lights.

Since the difference between *practical* and *ideal* cycles is much greater than the gains to be made by steam temperature increases, it would appear that the greatest economic gains are to be made by reducing these losses. The greatest gains probably lie in reduction of stack gas losses and exhaust losses. Both of these fields are being studied intensely at the present time.

Perhaps a breakdown of the heat distribution for a typical modern large coal-burning reheat steam power plant will be of interest:

Salable kilowatts	**39.6 per cent**
Boiler loss	**6.0**
Hydrogen in fuel loss	**4.0**
Unavoidable condenser loss	**34.5**
Turbine and feed cycle loss	**13.5**
Auxiliary power	**1.5**
Electrical loss	**0.6**
Mechanical loss	**0.2**
Boiler Feed pump loss	**0.1**
Total	**100.0 per cent**

It points up relative magnitude of losses which stand between actual performance and complete conversion into electrical energy of all heat energy that is present in the fuel. The above figures are for a 300-Mw, 2400-psig, 1050/1000-F, 1-in. Hg Absolute, 3600/1800-rpm cross-compound unit. THE END

HEAT POWER CYCLE DEVELOPMENTS

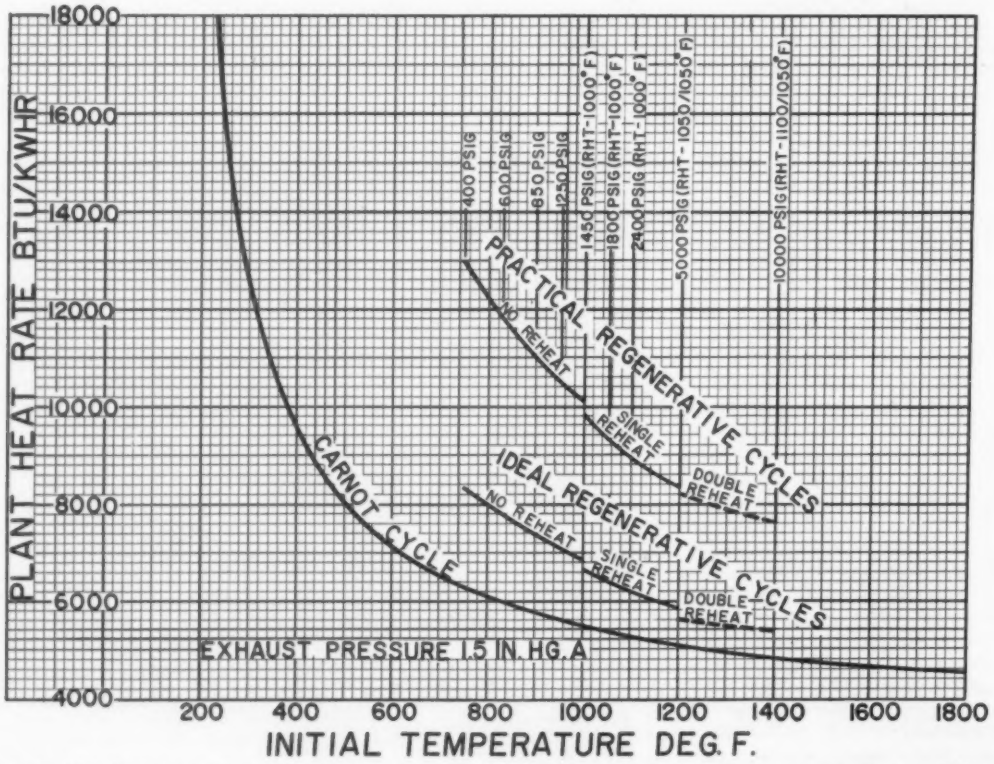


Fig. 3. Graph of heat power cycle developments points out differences among Carnot Cycle and practical and ideal cycles

Fig. 1. Aerial view of Dickerson Station of Potomac Electric Power Co

Many considerations are involved in selecting a site for a new power station. This article tells how development studies can provide valuable data on costs

How New Plant Sites Are Selected At Potomac Electric Co

By R. D. CHELLIS and E. IRELAND *

ECONOMIC VALUE of studies for site development is illustrated in the comparative cost estimates involving location in the property, building elevation, and arrangement of facilities for the Dickerson Station of the Potomac Electric Power Company near Washington, D. C.

Station is a coal-burning steam power plant with an initial installation of two 1,300,000 lb of steam per hour boilers operating at a pressure of 2486 psi gage at superheater outlet and temperature of 1050 F, with 1,090,000 lb reheated to 1000 F, and two 175,000-kw cross-compound, single-flow turbine generator units.

Analytical Studies

Irregular topography and wide variations in flow of the Potomac River called for unusually extensive analytical studies. These studies were made from a civil engineering viewpoint to secure the most economical lot plan arrangement, circulating-water system, and building elevation for the initial step, and which would also accommodate future needs in a convenient and economical manner, without foreseeable interferences or undue construction difficulties.

Relative costs found for this project, and conclusions drawn, would not apply under different conditions. Power plant sites are apt to vary widely. Types of investigations made, however, and the methods of approach to the problems, may be of value in other instances.

These Factors Were Weighed

Studies involved river water availability, types of circulating-water systems, heat balances, thermal efficiency of equipment, life of equipment, capability charges, and capitalized operating costs.

Studies of cooling tower and river intake cost differentials for initial and future units will also be of assistance in choosing between this and other sites for future additional units.

Studies of open and closed circulating-water systems allowed sufficient space to be provided on the lot plan for various arrangements.

Economic analyses of this type are one of the power plant planner's most difficult tasks, particularly since pressure is usually exerted to start working drawings and construction quickly, after the plant is authorized. Some decisions must even be assumed before the analyses can be completed.

Property was selected by Potomac Electric Power Co in its program of planning for future power requirements. As shown in Fig. 1, it is located on the easterly bank of the Potomac River near Dickerson, Md, about 35 miles above Washington, D. C.

Tract available covers about 1000 acres. Particular area selected for the station is within approximately 1.7 miles of the main line of the B & O RR running between Cumberland, Md, and Washington, D. C., providing a direct route for coal from the Maryland, northern West Virginia, and Pennsylvania fields.

Least Desirable Features

All plant sites possess some features that are less desirable when considering cost than those at an ideal site. In this instance, they are as follows:

Roughness of terrain, the ground surface varying generally from El. 325 to El. 215.

Large recorded variation in river level from approximately El. 190 to El. 230.

Protection required against presently predicted high water to El. 242, and possible future high water to El. 250 after construction of a proposed dam downstream.

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* Structural Eng'rs, Stone & Webster Engineering Corp

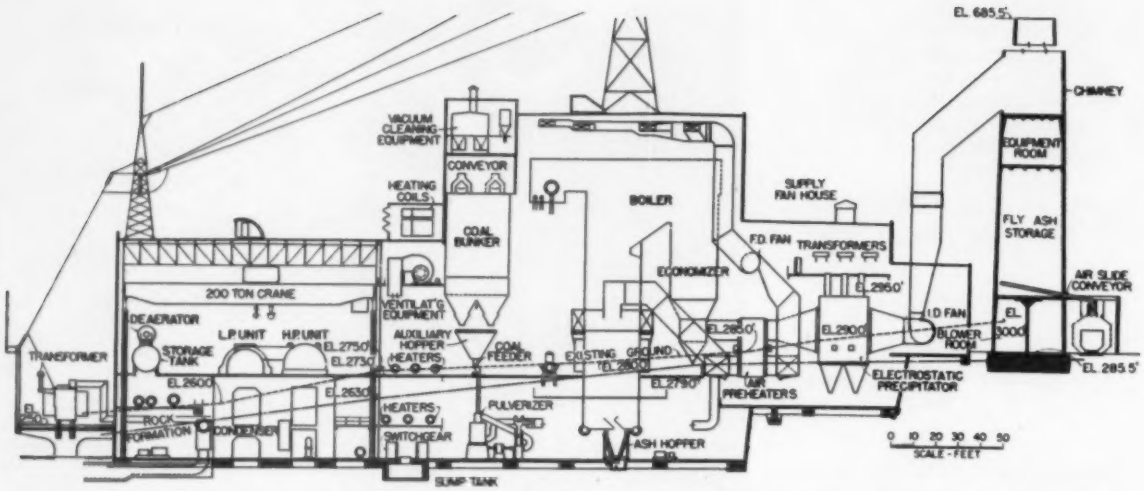

Fig. 2. This cross-sectional drawing shows how major machinery is arranged in Potomac Electric Power's Dickerson Station

Rock excavation, cut and fill, stepped levels.

The historic Chesapeake and Ohio canal separating a waterfront strip of about 20 acres from the remainder of the property.

Lengths of intake tunnels, and depth required to pass under the canal.

Possible need for a cooling tower with future expansion for Unit No. 4 and probable need for later units.

Lengths of intake and discharge penstocks for cooling towers north or south of the station.

Length of railroad spur, and lack of navigability of the river.

Favorable plant site features include:

Interbedded sandstones and shales for bearing of foundations, with overburden of from 5 to 15 ft of soil.

Ample space for expansion of power plant building and switchyard.

Large coal storage pile area with convenient coal car storage yard.

Convenient and ample ash disposal areas.

Locations Studied

Locations studied for the station were necessarily as close as possible to river water, laterally, to obtain cooling water at a minimum of expense. Relative costs of vertical locations involved combining substructure costs, which increased rapidly for lowering the condenser room floor, with capability and operating costs which generally decreased with lowered floor elevations. The general high level of the site falls off rather quickly near the riverbank, which is cut by gullies. For this reason, selection of an area where the least leveling would be required was desirable, with future expansion borne in mind.

Greater steepness of the bank elsewhere on the site indicated the general region of the southwest corner to be most practicable. This area is split by a valley. Locations facing the river north and south of this valley and along the side of the valley were considered, as shown in Fig. 4-A.

Comparison of principal features of locations is given in the table. Location D was discarded as being too cramped for outdoor switchyard facilities, railroad access, coal storage, circulating water and cooling tower arrangements, and future expansions.

General arrangement shown in Location C was selected over locations A and B for development because of lower excavation costs, proximity of switchyard to station, shortness of coal conveyor and its entrance into the permanent end, ease of expansion, and relationship to intake wells.

While this scheme would have per-

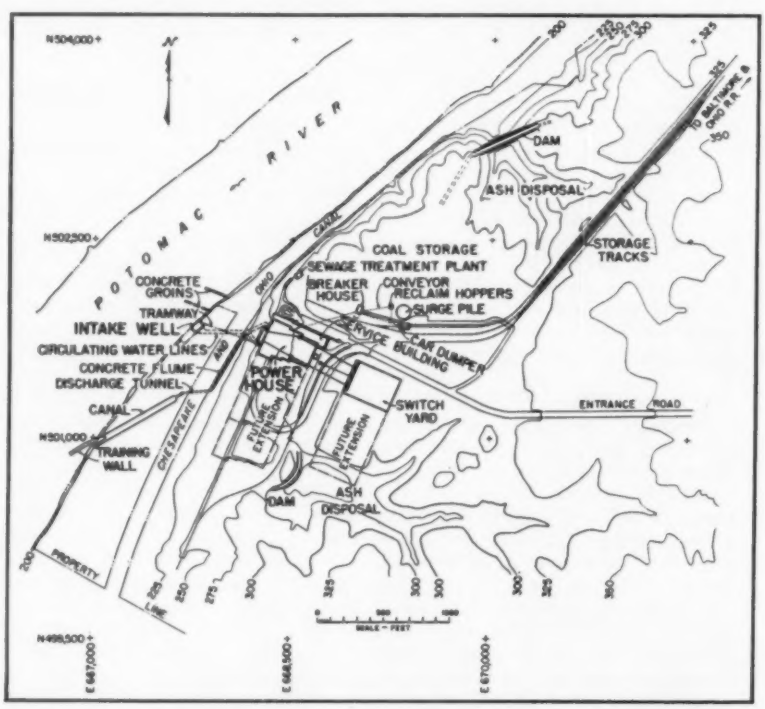

Fig. 3. Lot plan selected after all other possible arrangements were evaluated

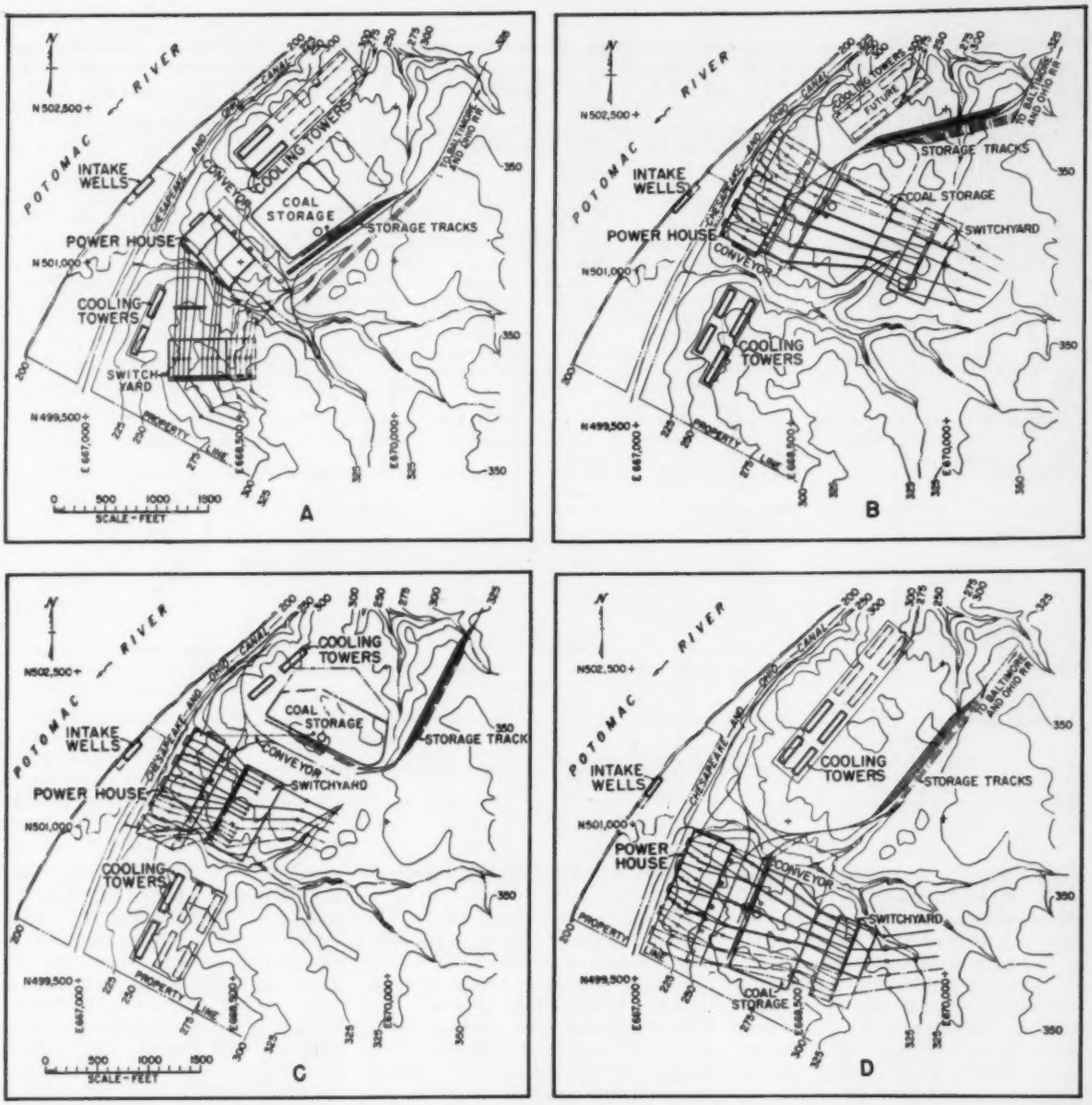

Fig. 4. These four alternate lot plans were considered and evaluated as shown in analysis presented on the next page

mitted the railroad to enter the turbine room at the permanent end, it was later decided to enter at the temporary end to avoid carrying construction materials for later extensions through the initial turbine room.

Unusual and somewhat disadvantageous necessity of crossing the roof with the electrical lines was outweighed by other factors. The preferred choices, indicated by asterisks in the table, are much more numerous for location C than for the other arrangements; none of the less satisfactory factors are unacceptable.

Lot plan has been developed as shown in Fig. 3, and the station cross section as shown on Fig. 2. As a result of circulating-water system studies, the station has been turned slightly and moved back from the C & O canal to provide space for initial and future circulating-water tunnels, discharge flume, and possible future penstocks.

Elevations Established

Elevations of the initial and future switchyard area, trackwork, roadways, and area between the canal and river were established to utilize rock and earth excavation from the station as fill. Rock at the location Unit No. 3 was shattered by blasting, but not removed, to avoid future blasting close to the building and equipment.

A railroad spur crosses a 300-ft-long bridge, expands into a car storage yard, and then descends on a three per cent maximum gradient to enter the temporary end of the turbine room by a Y. A level side spur from this track is used for cars to receive fly ash from storage space located in the lower portion of the stack. Supplies may be handled from the fly ash spur to the storage warehouse in the east end of the service building.

Sewage treatment plant and transformer oil tank are located north of the permanent end of the building.

Coal-handling facilities are also north of the station. Four initial storage tracks can hold 118 cars of coal, and 109 more cars can be stored

This table shows relative merits and economic evaluations of four alternate plans considered, as shown on preceding page

Item	Site A	Site B	Site C	Site D
Building Excavation				Not estimated
Units 1 and 2	$152,000 } $590,000	$98,000 } $432,000	$264,000 } $427,000	
Units 3, 4, 5 and 6	438,000 }	334,000 }	163,000 }	
Units 7 and 8	138,000	330,000	166,000	
	$728,000	$762,000	$593,000*	
Railroad	19,900 lin ft	18,500 lin ft*	18,500 lin ft*	21,200 lin ft
Railroad Spur to Turbine Room	Enters temporary end	Enters temporary end	Enters permanent end*†	Enters permanent end*
Switchyard	Future expansion easy. No lines cross roof. Electrical conduits to station cross ravine. Awkward angles between direction of lines and building, and between switchyard and final direction of lines.	High tension lines cross coal pile. Tall towers required; long distance from station. Lines cross station roof on towers. Future expansion easy. Long electrical conduits to station.	Close to back of station; lines cross roof on towers. Large fill for future extension. Short electrical conduits to station.*	High tension lines cross coal pile; long conduit. Long electrical conduits to station.
Transmission Towers Between Station and Switchyard (For 8 Units)	One bent in yard; none on building*	12 in yard (up to 190 ft high); 12 on building	None in yard; 12 on building	None in yard; 12 on building
Coal Conveyors	1,700 ft	1,200 ft	1,100 ft*	1,100 ft
Coal Pile	Near rear of station	Between switchyard and station	Near permanent end*	Near rear of station; site uneven
Relocation of Water Course	Required (approximately 189,000)	Not required*	Not required*	Bridging required
Cooling Towers	Good locations for towers for Units 3 and 4 south of station, balance north. (North towers partially shielded.)*	Good locations for towers for Units 3–6 south of station, balance north. (North towers partially shielded.)	Good locations for towers for Units 3 and 4 north of station, balance south. (North towers partially shielded.)	Distant locations
Circulating Water Penstocks to Cooling Towers	21,700 lin ft	21,600 lin ft	20,800 lin ft*	28,800 lin ft
Intake	Expansion downstream good*	Expansion upstream interferes with future water supply	Expansion downstream good*	Too far downstream, too near discharge
Future Expansion	Relatively inexpensive to east*	Excavation costly to north	Relatively inexpensive to south*	Relatively inexpensive to north*

*Indicates preferred arrangement. †Later preferred at temporary end.

in the future by the addition of three tracks. A clear track for 10 cars and a yard engine beyond the car dumper and a run-around track are provided.

Coal yard is at approximately El. 323, which is sufficiently high so that the conveyor over the tracks can continue horizontally into the conveyor space over the coal bunkers. Over 400,000 tons of coal can be stored in the indicated area in a pile 40 ft high.

Permission was obtained to cross the presently dry C & O canal on temporary fills and to excavate across it for construction of circulating-water tunnels, but the canal must be cleared at the close of work. The canal may be restored to form a portion of a canal park development.

Circulating-Water System

It was initially assumed that sufficient cooling water for at least two or, probably, three units could be diverted from the river at all times without appreciable recirculation. Model tests have confirmed this opinion.

Separate circulating-water system was provided for each unit, from the intake to a common discharge flume. No underground installations of any kind were placed where they would interfere with this future construction.

Large sums are involved in the selection of the circulating-water system for each unit. For Unit 4, approximate estimated costs are as follows: River intake system, $1,500,000; closed cycle cooling tower north of station, $3,250,000; river intake with closed cycle cooling tower north of station as stand-by, $4,000,000; and river intake with open cycle cooling tower southwest of station, $3,500,000.

Condenser Floor Elevation

Elevations from 223 to 247 for the condenser room floor were considered possible by varying the floor levels in the boiler room area to minimize rock excavation. To permit starting design drawings and to make comparative estimates, El. 235 was selected as a base, and differences in cost for variable items for other levels were listed.

Variations in cost between El. 235 and El. 247 were insignificant for units Nos. 1 and 2, with El. 235 the lowest value. Variations in cost between El. 232 and El. 235 were small for units Nos. 3 and 4, with El. 235 the cheaper. Elevation 232 appeared to cost slightly less than El. 235 for units Nos. 5 and 6, considered alone and operating only on intakes for an assumed 90 per cent of the time. Elevation 235 proved to be the most economical elevation not only for units Nos. 1 and 2, but for units Nos. 1 through 4, and for units Nos. 1 through 6, when considered in these groupings and sequences of installation. Elevation 235 was retained for the final design.

Project Supervision

Project is being designed and constructed by Stone & Webster Engineering Corporation under the general direction of Mr. L. W. Cadwallader, vice president and mechanical engineer of the Potomac Electric Power Company. THE END

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How Deere Plant Pressure-Fires A Spreader-Stoker Installation

By HOWARD H. REISMAN*

In a new industrial power plant filled with unique ideas, the pressurized spreader-stoker boilers are the most outstanding feature. Induced-draft fans are eliminated, and forced-draft units are sized for full pressure-drop through boilers. These units are believed to be first of their kind

RECENTLY, OUR COMPANY placed into service a new power plant which includes a number of novel features worthy of discussion.

One of the most unique ideas is the use of pressurized spreader-stoker-fired boilers. A description of this installation will be of interest to power engineers concerned with industrial power plants.

This plant was built to serve four separate manufacturing plants, in close proximity to each other, at Moline, Illinois. Preliminary engineering by the company's staff engineering department indicated a single plant would result in lower operational costs, despite a higher first cost.

A New "First"

Today, pressure-firing of gas and oil packaged boilers is standard procedure. Gas, and oil-fired power boilers have also been pressure-fired for some time. Pressure-fired pulverized-fuel furnaces and cyclone furnaces are comparatively late comers to the field, but there are a number of them installed. The industrial spreader-stoker-fired boiler has heretofore never been pressure-fired.

It was believed that major advantages would accrue to pressure-firing. These advantages can be listed as follows:

1. The elimination of the induced-draft fan. The forced-draft fan will, of course, be sized to take the full pressure drop through the steam generating unit and hence will be more expensive, but the cost of the single-fan installation will be substantially lower than the cost of the two-fan installation.

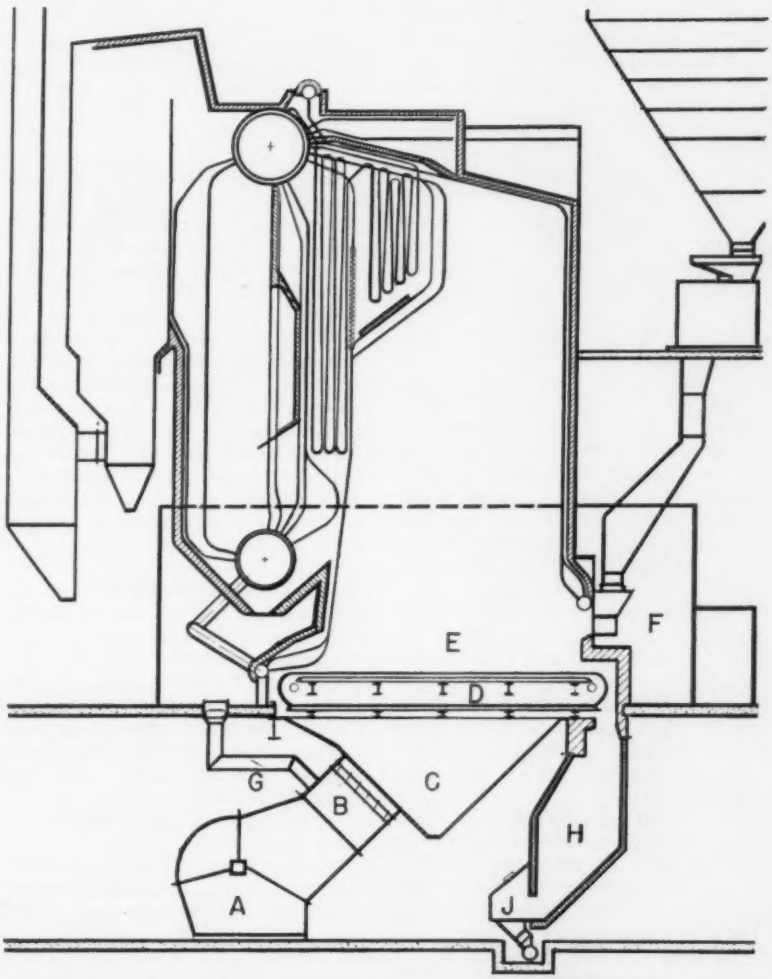

Fig. 1. Generalized spreader-stoker, two-drum boiler installation. Enclosure is on all four sides around lower end of boiler. Text describes pressure operations

2. In the normal draft-operated furnace, the boiler setting is usually tight to begin with, allowing a minimum of infiltrated air. The usual boiler setting, however, after a period of time develops leaks. These leaks may not be taken care of by the operating staff, since there is no particular discomfort to the operators with air leaking into the furnace. The efficiency will be less because of this air leakage.

In pressure-firing, however, an essential requirement is a sealed setting designed to be air-tight for the life of the boiler. Any leaks are immediately detected and repaired, due to the discomfort of gas leaking out of the furnace. A higher lifetime efficiency should result.

3. The usual combustion control on an industrial boiler has a control that will vary the fuel input to the boiler, dependent upon steam pressure, and a control that will vary the air input into the furnace (to hold the correct fuel-air ratio) regardless of the amount of fuel being fed into the furnace.

A third control normally operates either an uptake damper, or varies the speed of the induced-draft fan to hold a constant furnace draft. The efficiency of the boiler unit is due in no

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small measure to the original and continuous calibration of these controls, and to the interaction and speed of response of the forced-draft and induced-draft fans (or dampers) being controlled.

With pressure-firing, there is no necessity for holding a constant furnace pressure (or draft). One of the three controls therefore is eliminated, and the necessity for the correct action between this control and the other two is eliminated. The result, with the same degree of attention and calibration, must, of necessity, be better efficiency under normal operating conditions.

4. The induced-draft fan on the normal installation handles products of combustion, plus infiltrated air at the exit gas temperature. The volume of this gas, therefore, is substantially higher than the volume of the air handled by the forced-draft fan. Because of the higher volume of gas being handled, the horsepower of the induced-draft fan, plus the horsepower of the forced-draft fan on the normal draft-fired boiler, is substantially higher than the horsepower of the forced-draft fan that supplies air to a pressure-fired boiler. The reduced horsepower provides a marked savings in operating cost.

5. Even though the installation of efficient dust collectors reduces fly ash erosion of induced-draft fan blades, this erosion (with the necessary fan maintenance) is not eliminated. The elimination of the induced-draft fan itself, in the pressure-fired boiler, completely eliminates this fan maintenance.

6. In discussing the proposed pressure-firing operation with authorities in the field, an advantage cited by them was the idea that, under pressure-firing, the combustion gases would have a greater tendency to *fill* the boiler. This was accepted on face value, since superficial thinking indicated that under suction of an induced-draft fan, boiler gases would be pulled through the boiler, taking the most streamlined path and leaving many dead areas. Under pressure operation the gases would be pushed through and would be forced into all parts of the boiler itself; thus better heat transfer would occur.

Pressure Differential

Further thought on this matter, however, indicates that the boiler gases flow because of pressure differential, and that this pressure differential is approximately the same whether produced by a forced-draft fan at one end, or an induced-draft fan at the other end.

There are, however, two factors that should be taken into consideration in this improvement in heat transfer. First is that the boiler gases operate under slightly higher density, and therefore the heat-transfer coefficient is higher. Second, and probably more important, with pressure-firing there is no infiltration of cold air through all of the walls of the setting. In the normal draft boiler this infiltration will produce a cooler zone next to the interior wall, thus making the heat exchange surfaces near the outside walls less effective than those surfaces closer to the center of the boiler.

Recognizing the above advantages, the next step was to devise a method of operating, under pressure, with a major consideration being the utilization of standard components. The basic method evolved is shown in Fig. 1.

This figure shows a generalized spreader-stoker, two-drum boiler installation. The major difference between this installation and the usual spreader-stoker installation is the enclosure around the lower end of the boiler. This enclosure is on all four sides of the boiler. It is reasonably air-tight, and is entered through a revolving door.

Pressure Operation

Pressure operation is as follows:

Air from fan (A) is discharged, through control damper (B), into plenum chamber (C), and up through grate (D) into the furnace (E). Damper (B) is controlled by the usual fuel-air ratio controller. Pressure in furnace (E) will vary, depending upon the pressure-drop from the furnace through the boiler superheater, economizer, dust-collector, duct work, and on out through the short stack.

A differential-pressure controller is set to maintain a fixed differential-pressure between enclosure (F) and furnace (E). It maintains this fixed differential-pressure (approximately 0.10 to 0.12 in.) by varying the position of damper (G). Since the pressure drop across grate (D) varies from a minimum of perhaps one-half in. to three in., the pressure output of fan (A) is always high enough to maintain a higher pressure in enclosure (F) than in furnace (E). A small amount of leakage from enclosure (F) is not serious, since this leakage is cold air rather than noxious gases.

Leakage Prevention

The non-segregating coal chute above the spreader-stoker hoppers is sufficiently high so that the column of coal will prevent any upward leakage of gases. Here, again, if there should be any leakage, it will be cold air from the enclosure, rather than combustion gases. The ash pit (H) is under pressure. At the disposal period, the ashes flow into the intake of the pneumatic ash conveyor. Observation of this flow was accomplished by installing a small air-inspirating-type pressure door at the top of the enclosure (J) around the ash intake.

There are two noteworthy design details in this installation. The first is *gravity reinjection of fly ash*. The general idea of gravity reinjection of fly ash, both from boiler hoppers and dust collectors, has been discussed in literature before. Suffice it to say that this particular phase of this installation is quite successful, and it is

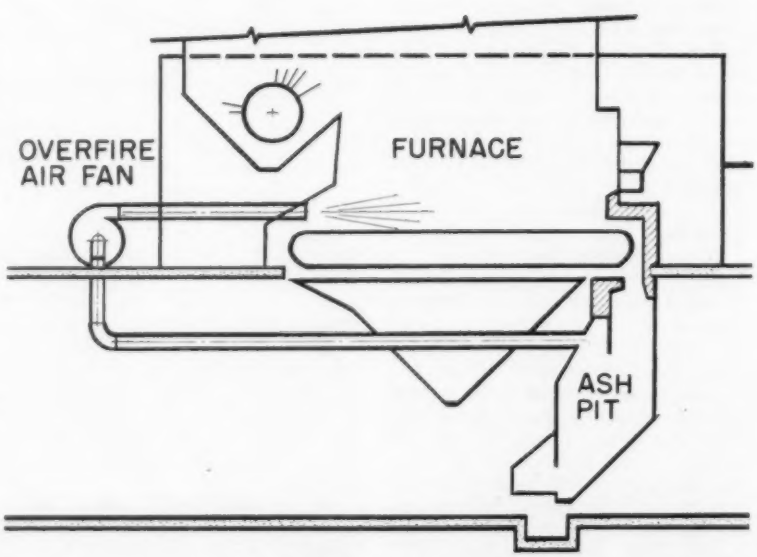


Fig. 2. Schematic shows recirculation of over-fire air. Suction for over-fire air fan is taken from ash pit; constant quantity of air recirculates through furnace

one of the factors in promotion of an extremely clean furnace.

The second feature is *recirculation of over-fire air*. This is shown schematically in Fig. 2. In theory, over-fire air is required to produce turbulence and is, therefore, most essential during the stratification in the furnace that occurs at low loads. Although some installations attempt to control over-fire air to decrease the quantity at low loads, this is contrary to theory; and, on this installation, over-fire air is uncontrolled.

Air Recirculation

Suction for the over-fire air fan is taken from the ash pit, as shown. Thus, this constant quantity of air recirculates through the furnace, where it is needed to produce turbulence, but is not added to the flow of gases through the boiler. The duct work does not become too hot because, in addition to furnace gases, leakage air around the stoker seals also finds its way into the ash pit and into the over-fire air fan.

The boiler manufacturer was quite enthusiastic about the pressure-firing idea, and coöperated in the design. In fact, the idea of recirculation of the over-fire air was offered by the boiler manufacturer.

The pressure enclosure and revolving door were designed by our own engineering department, and were fabricated locally.

Preliminary operation of the boilers was attained during October, 1959. The other plants being replaced by this Central Power Plant were shut down as of November 1, 1959.

Most of the first month's operation was on manual control, since the combustion controls were being adjusted during the interim. Even with manual control, it was noted right from the start that the pressure-firing feature was not to be a problem.

One of the initial questions in the design stage was the possibility that the operator would get claustrophobia and become frightened, once inside the enclosure. The enclosure, however, is large, very well lighted, and has windows in the walls so that the operator can see outside. There has been no hint of this problem.

A problem that did develop, however, was in the method of handling ashes. With manual operation of the boilers, correct fuel-air ratios could not be obtained at all times and some ash clinkering developed. These clinkers became difficult to force into the pneumatic ash intake since the pressurized observation door (which doubled as a poke hole) was quite small in diameter.

Clogging of the ash hopper resulted in two cases necessitating taking the boiler off the line for cleaning of the ash hopper.

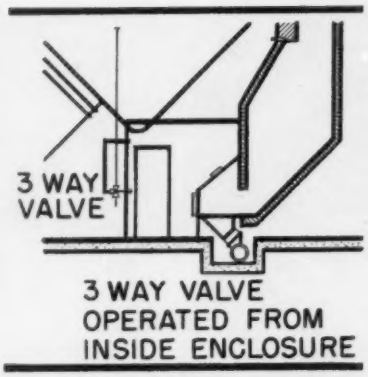


Fig. 3. This pressurized housing allows ash handler to achieve good combustion control, as described below in text

The problem was virtually eliminated with the advent of good combustion control. The possibility, however (in burning low-grade midwestern coals), of clinker formation on the grate always exists. With this thought in mind, a change was designed and installed for the ash-removal system.

The change is shown in Fig. 3. It is, in effect, a pressurized housing which allows the ash handler to enter the housing, bring pressure up within the housing through the system of manual valves, open the ash enclosure door, watch the ash go down to the pneumatic ash conveyor, and do some small amount of raking of the ash as it becomes necessary.

Efficiency Test Made

An efficiency test was run, under the supervision of the manufacturer's representative, on one of the boilers on December 18, 1959. The boiler was burning northern Illinois strip-mine coal, having 10,856 Btu's per pound, as fired. The test heat balance data is shown at top of next column:

Fig. 4. View from outside of new Deere Plant housing the unique installations

	Per Cent
Heat loss due to moisture in fuel	1.94
Heat loss due to hydrogen	4.18
Heat loss due to moisture in air	0.17
Heat loss due to dry flue gas	6.55
Heat loss due to combustibles in refuse	0.32
Heat loss due to radiation (ABMA)	1.20
Heat absorbed by unit (Efficiency)	85.64
TOTAL	100.0

Average CO_2 = 12.8 per cent = 43 per cent excess air
Average load = 85,000 lb per hr

The high efficiency indicated is interesting when it is noted that the predicted efficiency at the average load shown is 84.9 per cent. Also this efficiency is obtained with 13.7 per cent CO_2, corresponding to 32 per cent excess air. In addition, during the period the test was being run, the boiler was carrying the normal factory load. This swinging load, too, made the test more difficult.

On the basis of steam output vs coal input readings, spot checks during normal operation in January show efficiencies ranging from 85.2 to 87.1 per cent.

Conclusion

This article has attempted to illustrate some of the novel features that imaginative power plant engineering can develop. While, in general, most of the novel features are in details, the rather basic development of the pressurized stoker-fired boiler has been discussed. Since this development was pioneering, it was essential that all of the engineering details be as conservative as possible.

As a matter of fact, the pressurized enclosure for ash removal had been worked out during the original design. In addition, an induced-draft fan arrangement was given some attention during the original design period, so that if it became necessary to install such a fan in the future, it could be accomplished.

Although the two boilers have not been in operation a sufficiently long period to completely evaluate this addition to the art, the evidence we already have indicates that the system is very workable and that the problems are few. The pressurized-firing method, therefore, can be considered in addition to the usual draft operation when designing a new boiler installation.

Editor's note: This article is part of a paper given by the author, at the American Power Conference this year. It is published through the courtesy of the Conference authorities.

Since some of the other plant details are so interesting, a later article will describe them. THE END

Leading American engineers in World of Large Dams at annual meeting in Washington detail plans for future activities

World Wide Dam Activity Booms

US Committee on Large Dams meets to review recent international meeting in Finland, plan future meetings in Reno, Tokyo and Rome, and coördinate technical programs with other ICOLD National Committees

THREE significant trends were manifest at the annual meeting of the US National Committee on Large Dams, USCOLD, recently held in Washington, D.C. First, increasing world wide activity in the construction and technology of dams for power, flood control, irrigation, and municipal water supplies. Second, the increasing role these dams play in the industrial, social, economic and political life of most nations. Third, the increasing participation of American engineers in the financing, planning and building of these dams around the world.

USCOLD, now with over 450 individual and company members, is the US branch of ICOLD, the International Committee on Large Dams, originally started as an activity of the World Power Conference. USCOLD headquarters are in the office of the Engineers Joint Council, 29 West 29th Street, New York City, and the secretary is Gen. Stewart E. Reimel.

Individual member dues are $10 a year, which entitle the member to a substantial discount on the many ICOLD publications and the recently initiated USCOLD News Letter. Large dams are defined by ICOLD as those of 50 ft and higher.

USCOLD was host in 1958 to the Sixth International Congress of Large Dams held in New York City. The proceedings of this congress, in several volumes, are now being completed in Paris and should be available for sale to members shortly. The Seventh International Congress will be held in Rome in October, 1961. By precedent each Congress is built around four questions. At the Executive Committee meeting in Helsinki last year the four questions selected for the Rome meeting, with the numbering carried on from the first congress, are:

24. The selection, processing, and specification of aggregates for concrete for large dams.

25. Underground works in connection with the design and construction of large dams.

26. Modern techniques of concrete dams and ancillary works for wide valleys.

27. Sealing of earth and rockfill dams with bitumen and other materials.

Responsibility for developing American papers on these topics for the conference lies in the Technical Activities Committee of which George Palo of TVA is chairman. Final selection of the papers to be presented as the American contribution will be made by another committee not yet appointed.

In the meantime the Committee has been active in developing a joint meeting with the ASCE to be held in Reno on June 20 and 21, 1960. This is in conjunction with the ASCE summer meeting, and the joint sessions have been in the planning stage for over two years. A feature of special interest to USCOLD is a field trip on June 24 to the Upper American Power Development and the associated dams.

Later in the year the ICOLD Executive Committee will meet in Tokyo as guests of the Japanese National Committee. The meeting will be held from October 15 through the 18th and will be followed by a 10-day study tour of Japanese installations starting October 19.

One of the major projects undertaken by USCOLD was the US Register of Dams, compiled by Ted Mermet. This proved to be so successful that a World Register will list dams in chronological order with measurements in both English and metric units. The cost of bringing the US Register up to date and changed so as to be consistent with the World Register was estimated at $1500. USCOLD authorized this expenditure, and the volume should be available by mid-1962.

Among the notable dam failures in history was the comparatively recent failure of the Malpasset thin arch dam in France. The dam had been in service for some time but due to legal difficulties was filled completely for the first time just prior to the failure. Indications are that the initial break was at the left abutment due to a fault in the bedrock. THE END

Fig. 1. First stage of system is barometric condenser (immediately left of center) with water supplied from cooling towers (right). Steam ejectors are also on top of laboratory

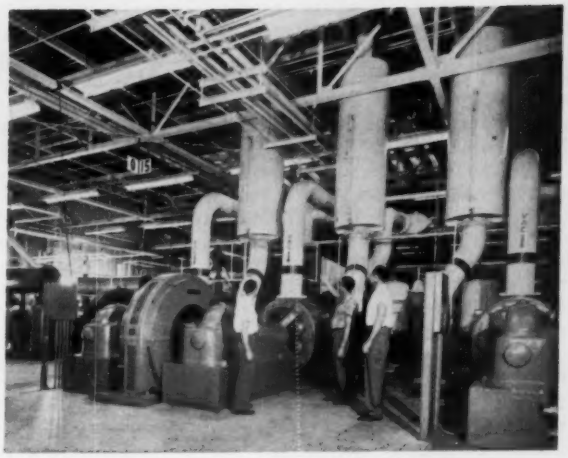


Fig. 2. Second stage of the condensing unit consists of two duplex vacuum pumps each with a capacity of 9000 cfm. Four mufflers on exhaust outlets reduce noise to comfort level

Here's a Vacuum System for Testing

By RALPH M. ANDERSON *

IMPROVED vacuum system for development and testing of the aircraft and misiles components it manufactures has recently been installed in test facilities operated by the AiResearch Manufacturing Division of the Garrett Corp in Phoenix.

Classed as a two-stage condensing unit, the system consists of a disc-flow barometric condenser D-F 120, with water supplied to the condenser from a cooling tower with a capacity of 53,900,000 Btu per hr and an evaporation rate of 108 gpm. Raw water make-up consists of 64 gpm and steam condensate of 80 gpm for a total of 144 gpm. Flow rate to and from the towers is 2250 gpm. The system was designed to AiResearch specifications and produced by Ingersoll-Rand.

In the primary system, two jet-air ejectors consume 56,000 lb per hr of steam generated by two water-tube high-pressure boilers. Built by Babcock and Wilcox, the boilers operate at capacity 24 hours a day. They are fed with 100 per cent make-up water using zeolite-softened water. In five years' time we have had no malfunction or need for cleaning.

Two single-stage reciprocating duplex vacuum pumps, using 36 by 14-in. cylinders with a 9000 cfm displacement, comprise a secondary system.

In six cabin-atmosphere tanks the

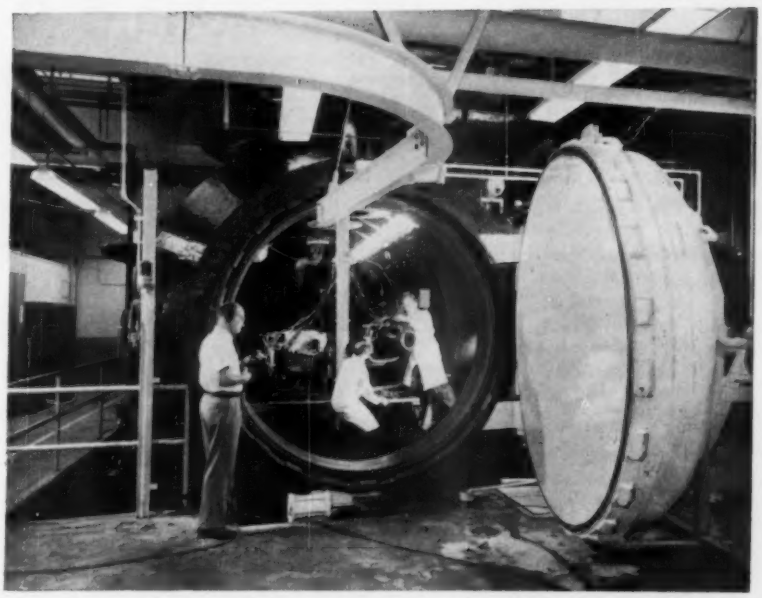


Fig. 3. System is used to duplicate altitudes in this chamber from 1000 ft below sea to 76,000 ft, from —75 F to 500 F. Here gas turbine is readied for test

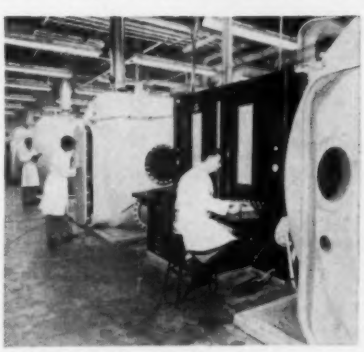


Fig. 4. Cabin altitude tanks are partitioned in middle, can produce ambient or outside air conditions in one half, cabin conditions in the other, for system-created altitudes up to 90,000 ft

* Chief operating engineer, AiResearch Manufacturing Div of the Garrett Corp, Phoenix, Arizona

system is used to duplicate altitudes from sea level to 90,000 feet. These tanks are 9 ft in diameter and 16 ft long with an approximate air volume of 1000 cu ft. Tank temperatures produced range from 80 F to minus 75 F.

The vacuum system also serves an altitude-cold chamber 14 ft in diameter by 28 ft with a volume of 4500 cu ft. Capacity of this chamber is from sea level to 76,000 ft, with a temperature range of 500 F to minus 75 F. Maximum controlled climb and dive rate for the chamber is 70,000 fpm.

The large chamber has a brine cooled-steam heated jacket. Access is through an 8-ft-diameter door. A porthole provides visual observation from a completely-instrumented external control panel for operating it.

Operation of the system follows a short vacuum pump warmup. The pumps are loaded and the system then evacuated.

Cooling tower and hot well pumps are next started to supply water to the barometric condenser, entering from the top. After water flow is established steam flow is started through ejectors. The steam leaves the ejectors to enter the barometric condenser at a point near the bottom.

As the water passes through the steam, condensing it, air is released to pass upward through the descending water. After being cooled and devaporized, the air is removed by the vacuum pump from the top of the barometric condenser.

To prevent water from reaching vacuum pumps, condensate drain tanks and separators are used. Pump controls and steam supply valves are interlocked to keep steam from getting into the vacuum pumps or system.

AiResearch has found maintenance requirements on vacuum pumps to be very low. A 90-day inspection of cylinders and valves is made. Valves showing signs of wear or need of cleaning are then replaced.

As an added safety precaution a lubricant is used which will emulsify with water, in the event moisture should reach the vacuum pumps. AiResearch uses Almo oil No. 5, specially compounded by the Socony-Mobil Co. THE END

Power Conference Meets in Madrid, June 5-9

Fig. 1. Covering WPC sessions is a part of POWER ENGINEERING's service to readers. Here are (l to r) editors Kramer, McCaw, Earle and Morris at Montreal meeting in 1958. Meeting in Madrid will be covered, too

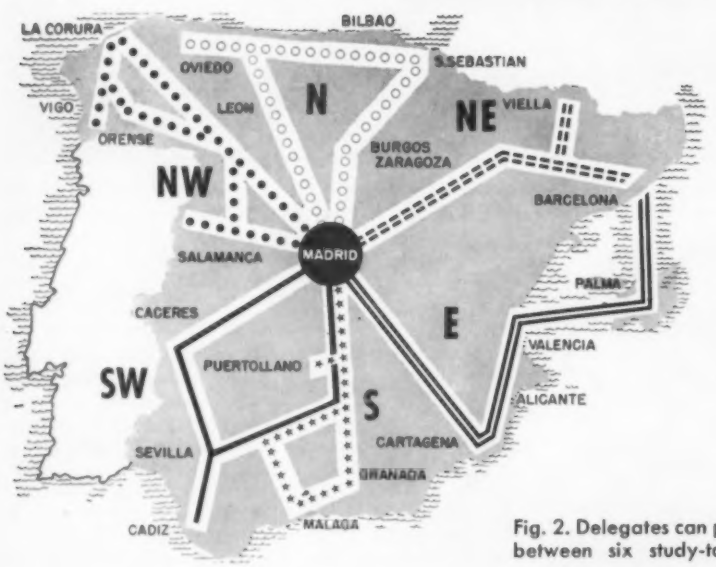


Fig. 2. Delegates can pick between six study-tours

NEXT sectional meeting of the World Power Conference will be held in Madrid, Spain, June 5 to 9. Plenary sessions of this international power organization are held every six years, with sectional meetings more frequently. First plenary session met in 1924, last plenary session in Vienna in 1956. Last sectional meeting was held in Montreal in 1958. This Madrid sectional meeting immediately precedes the 1960 sessions of CIGRE (International Conference on Large Electric System), also being held in June, from the 15th to the 25th, in Paris.

General theme of the Madrid meeting is Methods for Solving Power Shortage Problems. Sessions will be held in the National Institute of Industry in the Plaza de Salamanca. D. Juan Antonio Suanzes, president of the Institute, is chairman of the Spanish National Committee of the World Power Conference, which has arranged the meeting. President of the WPC is Franz Holzinger of Austria.

Working languages at this Madrid sectional meeting will be English, French and Spanish.

In addition to the working sessions, there will be several visits scheduled to plants in or near Madrid, alternating with excursions to points of cultural interest, and a full program for the ladies. Also, six study-tours are being offered immediately following the Conference. Radiating from Madrid (Fig. 2), these will show delegates something of the varied scenery of Spain.

American engineers attending the Madrid meeting should register through the U. S. National Committee of WPC, care of Engineers' Joint Council, 29 W. 39th Street, New York 18, N. Y.

This is a detailed description of the complete electrical system in a large foundry, and shows the full scope of one type of power engineering. Total electric load amounts to 25,000 kva, and is fed at 66 kv. The foundry produces 3000 tons of finished castings each month

All-Electric Foundry Uses Heavy Power

By BILLY L. DEMMON *

THE LFM Manufacturing Company, a subsidiary of Rockwell Manufacturing Co, is an Electric Steel Foundry with machine shops, totaling a production capacity of 3000 tons of finished steel castings a month. These castings (weighing from 100 to 35,000 pounds) are finished parts for the oil, gas, chemical, locomotive, and road-building machinery industries.

Our electric power is purchased from the local power company with a peak demand of 25,000 kva. This power is supplied at 66 kv to our primary outside substation.

The primary substation consists of four transformer banks:

1. One 6000-kva, three-phase, 60-cycle bank, consisting of three 2000-kva single-phase transformers, connected 66-kv three-phase delta primary, and 13.8-kv three-phase delta secondary. This bank supplies two circuits, each of which goes through an oil circuit breaker, to overhead secondary distribution lines. These two lines supply power to two electric furnaces.

2. One 7500-kva three-phase bank, consisting of one 7500-kva three-phase transformer, connected 66-kv delta primary, and 13.8-kv delta secondary. This transformer supplies power, through a circuit breaker, to an overhead secondary distribution line. This line supplies power to a third electric furnace.

3. One 5000-kva, three-phase bank, consisting of one 5000-kva three-phase transformer, connected 66-kv delta primary, and 4.16-kv wye secondary, with the neutral grounded. This 5000-kva bank supplies power to four overhead secondary distribution circuits. Each circuit is protected with fusable disconnect switches.

These circuits supply power to:

a. A 1000-kva loadcenter (east); b. a 1000-kva loadcenter (west) and a 125-kva pattern shop loadcenter; c. a 1100-kva loadcenter (north); and d. one 350-hp synchronous motor.

4. One 3000-kva, three-phase bank, consisting of three 1000-kva single-phase transformers, connected 66-kv three-phase delta primary, and 2.3-kv three-phase delta secondary. This bank supplies power to three overhead secondary circuits. Each circuit is protected with fusable disconnect switch.

These circuits supply power to:

a. One 1200-kva loadcenter (west); b. one 1650-kva Shop I loadcenter (west); and c. two synchronous motors, 215 and 350 hp.

Distribution System

We also have a 2300-volt line that feeds from the city bus to a 205-kva loadcenter, and a 600-hp synchronous motor at the north end of the plant. This line is entirely separate from the main plant substation.

Our secondary distribution lines are all bare overhead — either copper or aluminum (ACSR). We used existing copper because it was already on hand; new lines were all aluminum (ACSR).

Electric furnace line sizes were determined by using ½-per cent voltage drop, because of the high momentary current surges; all other line sizes were determined, using one per cent allowable voltage drop.

Because of our weather conditions, the sag in our various overhead lines was determined by assuming heavy loading conditions: ½ in. of ice, 4-lb wind at 0 F, with the tension not to exceed one-half the conductor ultimate strength. Lines were installed at 85 F. These sags were determined by using the tables in the Electrical Engineers Handbook.

Overhead lines were supported on stand-off-type insulators, and deadended with strain clamps. On the aluminum (ACSR) conductors, we used aluminum alloy line guards, where they are supported by insulators to protect them against clamping, tie-wire damage, and flashover burning. Split-bolt connectors were used on all aluminum-to-aluminum and copper-to-aluminum connections.

Our 2.3-kv secondary distribution system supplies power to three circuits:

1. 1650-kva west side shop I loadcenter. This loadcenter consists of:

a. One 750-kva three-phase bank, of three 250-kva single-phase transformers, connected 2.3-kv three-phase delta primary, and 230-v three-phase delta secondary; b. one 500-kva three-phase bank, of three 167-kva single-phase transformers, connected 2.3-kv three-phase delta primary, and 230-v three-phase delta secondary; c. one 300-kva three-phase bank, of three 100-kva single-phase transformers, connected 2.3-kv three-phase delta primary, and 230-v three-phase delta secondary; and d. one 100-kva

*Power Engineer, The LFM Mfg Co, Inc, a subsidiary of Rockwell Mfg Co, Atchinson, Kansas

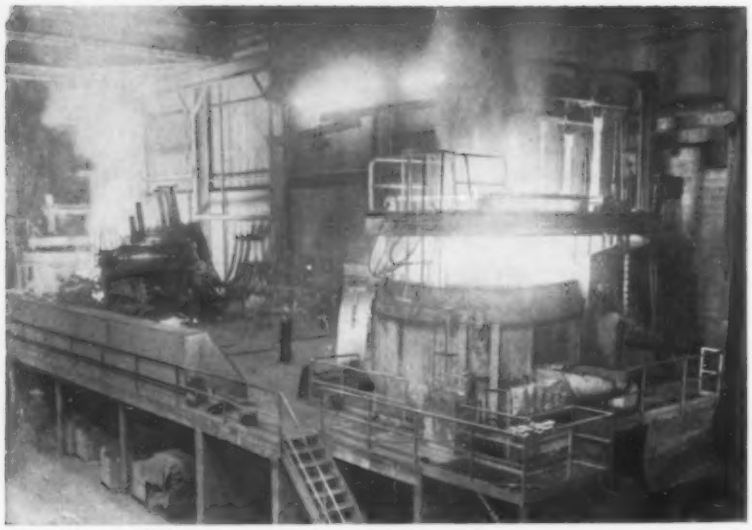


Fig. 1. These three electric furnaces are the big power-consumers in the all-electric foundry. Operating cycle, and heavy demand, require separate substations

single-phase transformer, connected 2.3-kv primary, and 230/115-volts single-phase secondary.

This loadcenter is fed with 266.8 mcm ACSR. Each transformer bank is supplied power through fuse cutouts. The transformer bank secondaries are fed through air circuit breakers to heavy machine shop equipment. All feeder lines out of this loadcenter have type RH insulation and are run open on secondary racks.

This same secondary distribution line also supplies power for two 550-v d-c, 60-kw motor-generator units. These generators are driven by 90-hp 2300-v synchronous motors. These motor-generator units are used to supply power for overhead traveling cranes in the machine shop area, and some cranes in the cleaning area. One unit is on the line, and the other on standby, at all times.

2. 1200-kva west IF loadcenter, which consists of:

a. Two 300-kva banks, each consisting of three 100-kva single-phase transformers, connected 2.3-kv delta primary, and 230-v delta secondary; b. one 500-kva bank of three 167-kva transformers, connected 2.3-kv delta primary, and 230-v delta secondary; and c. two 100-kva transformers, connected 2.3-kv primary, and 230/115-v single-phase secondary.

This loadcenter is fed with 266.8 mcm ACSR. Each transformer bank is fed through fused cutouts. The transformer bank output supplies power for light and medium-heavy machine shop equipment and for miscellaneous core room and heat-treating equipment. All feeder lines out of this loadcenter have type RH insulation, and are run open on secondary racks.

3. 215- and 350-hp synchronous air compressor motors. This line is 2/0 copper, fed through fused cutouts to synchronous motor controllers. These motors drive air compressors which deliver 1200 cfm and 2000 cfm, at 100 psi.

Air Compressor Load

1. A 350-hp synchronous motor, 4160 v, 450 rpm. This motor is fed with a #6 ACSR line, through fused cutouts, to an automatic synchronous motor controller, with a polarized field frequency relay for field excitation voltage application.

This motor drives an air compressor with a capacity of 2000 cfm, at a discharge pressure of 100 psi.

2. The 1000-kva east side loadcenter. This loadcenter is a substation transformer, connected 4.16-kv delta primary, and 480/277-v wye secondary, with neutral grounded. This loadcenter is fed by #2 ACSR, to a dead-end rack on the roof; then, with 4/0–5000-v cable down from roof, in 3-in. rigid conduit, through fused cutouts to the transformer.

This loadcenter consists of one 600-amp main air circuit breaker and four 600-amp feeder air circuit breakers. It supplies power for cleaning-room welding and motor-generator units, overhead traveling cranes, miscellaneous cleaning-room equipment, and heat-treating facilities. All feeder lines out of this loadcenter are type RH insulation, run open on secondary racks.

3. The 1100-kva north end loadcenter, which consists of two 500-kva transformers, connected 4.16-kv delta primary, and 480-v delta secondary. This loadcenter also has a 100-kva single-phase transformer, connected 4.16-kv primary and 230/115-v secondary.

This loadcenter is fed with 4/0 copper overhead lines, to a dead-end

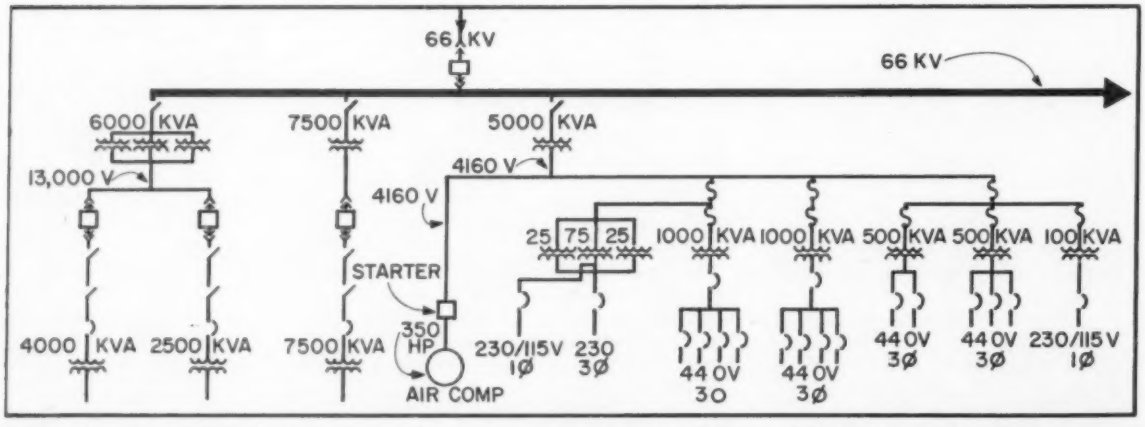


Fig. 2. Schematic diagram showing incoming 66-kv primary, three furnace feeders, and 4160-v bus to other unit load centers

rack on the roof above the transformer. The line from roof to transformer is 4/0, 5000 volt, in 3-in. rigid conduit. This line goes through fused cutouts to each transformer.

This loadcenter supplies power for sand mixers, dust-collecting units, cleaning-area welding and motor-generator sets, shot-blast rooms, and other miscellaneous cleaning-area equipment. The feeder lines coming off of this loadcenter are type RH insulation, run open on secondary racks.

4. The 1000-kva west side loadcenter. This loadcenter has a unit substation transformer, connected 4.16-kv delta primary and 480/277-v wye secondary with neutral grounded. It is fed with #2 ACSR and consists of one main (1600 amps) and four 600-amp feeder air circuit breakers. It provides power for the main foundry overhead traveling cranes, all sand-handling equipment, and miscellaneous foundry and melting-area equipment.

This distribution line also supplies power to the pattern shop 125-kva loadcenter. This loadcenter consists of one 75-kva and two 25-kva transformers, 4.16-kv wye (ungrounded) primary, and 220-v three-phase delta secondary. The 75-kva transformer also supplies 230/115-v single-phase power. All feeder lines out of this loadcenter have type RH insulation run in rigid conduit.

Electric Furnace Load

Primary substation transformer is 7500-kva, 66 kv primary and 13.8 kv secondary. This line is fed through a 15,000-amp oil circuit breaker to a 360.8-mcm ACSR overhead line, dead-ended on the roof above the transformer vault.

Two circuits run down from the roof and consist of three 4/0, 15,000-v cables, in 5-in. conduit. These lines come in to an air circuit breaker which feeds a 7500-kva three-phase transformer. (This is oil-filled, water-cooled.) Primary voltage is 13.8 kv; secondary is 250, 180, 120 and 90 volts, with a motor-operated remote-controlled tap changer.

Another electric furnace is supplied by a primary substation, 6000 kva, consisting of three 2000-kva single phase transformers, connected 66 kv primary and 13.8 kv secondary. (This transformer bank also supplies power to the size P.T. electric furnace).

One 4/0, 15,000-v circuit goes through disconnect switches to an air circuit breaker, 13.8 kv, 150 amps. This feeds a 4000-kva transformer, oil-filled, water-cooled.

P.T. Electric Furnace Load

This furnace is supplied power from the same primary substation transformer bank as the O.T. furnace. The line goes through disconnect switches, to an air circuit breaker, 13.8 kv, 150 amps; this feeds a 2500-kva transformer, 13.8 kv primary, and secondary of 240 volts and 138 volts.

All electric furnace transformers and switchgear are located in separate concrete vaults. The tap changers and air circuit breakers are remote-controlled from furnace main control panels.

We also have a 600-hp synchronous motor in the north end of the plant. This motor is supplied 2300-v power from the city bus. This motor is used to run performance tests on the 600- and 1250-hp mud pumps.

Our sand-handling equipment power demand is about 700 kva. This is divided up into four main sub-feeder control centers, two sand-shakeout systems, one drag pump and a sand-reclamation system.

We have 46 overhead traveling cranes, with a combined total capacity of 500 tons. These cranes vary in capacity from 3 to 50 tons.

In the last three years we have converted all feeder voltages from 220 to 440 v in all areas of the main foundry. This has reduced the initial cost of installing secondary feeder lines while improving voltage regulation. This changeover has also saved a substantial amount in motor-repair costs.

At the present time we are giving a considerable amount of thought to the use of capacitors, strategically located on our system, in an effort to improve our plant power factor and voltage regulation.

Our plant is supplied by a 65-mile transmission line. The electric furnaces consume 85 per cent of the total power used. During certain stages of the melt-down cycle, the furnaces demand momentary very high current surges which cause the bus voltage to fluctuate considerably during this period. This voltage fluctuation is reflected back through our entire system and presents several problems we are trying to overcome at the present time. The older plant equipment functions normally with this voltage fluctuation condition; however, the newer type control systems, and electronic measuring and recording devices, do not function properly under these conditions. This is being corrected. THE END

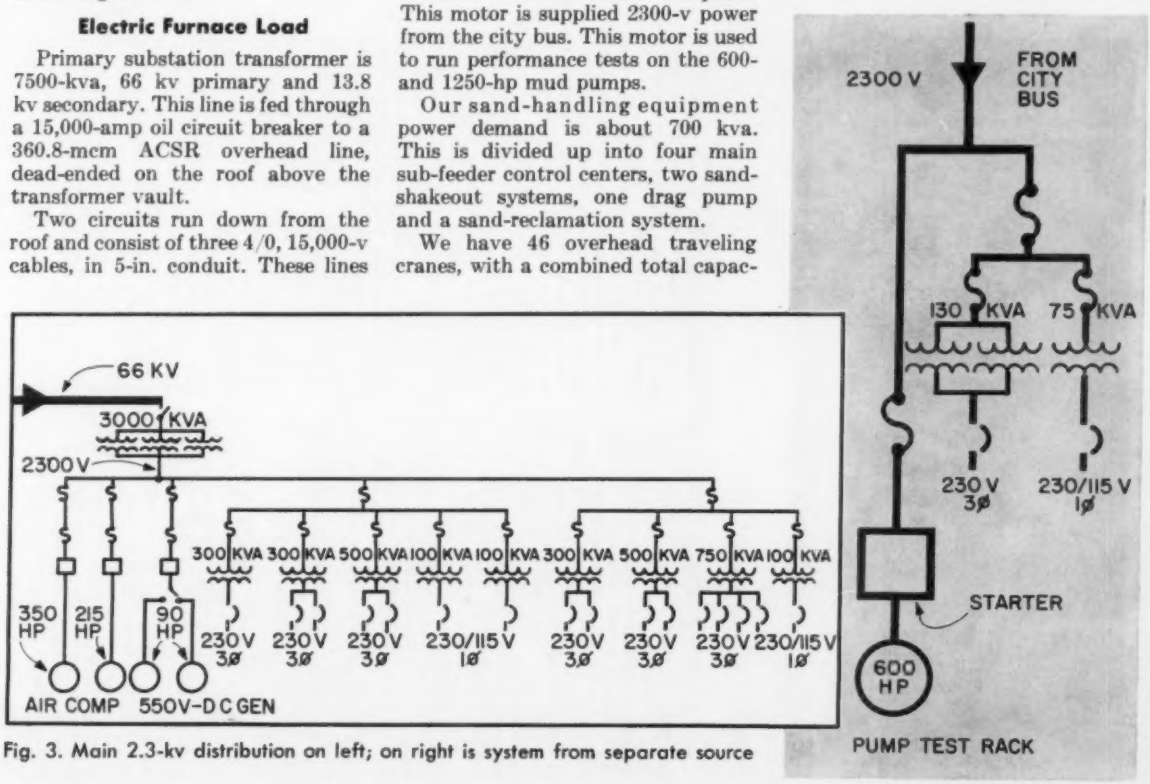


Fig. 3. Main 2.3-kv distribution on left; on right is system from separate source

Power Engineering handbook

Tracking Down Those Extra-High Power Costs

By C. T. BAKER*

IT IS EASIER to blame the power company or that "fast" electric meter than to look for possible trouble within the plant itself, that might explain most of the excess power cost which management may be complaining about.

Owners of a food-processing plant complained about monthly power bills, claiming that the cost of power, when considered on the basis of their total connected motor horsepower and five-day week operation, was out of line.

Of the total installed motor horsepower, approximately 70 per cent was required by the refrigerating plant, which included three ammonia compressors and one small Freon-12 compressor. The Freon machine was used to refrigerate a small storage room which was held at 34 to 36 F.

Two of the three ammonia compressors were 6¼ by 6¼ in., bore and stroke, and the other was a 7¼ by 7¼ in. machine.

Suction line from each of the three processing units was installed as shown in the sketch. By this arrangement the processing units could be operated independently of each other, each unit being served by a separate compressor or all three units handled as a group.

The larger compressor was driven by a 50-hp motor, while the two smaller units were driven by a 30-hp motor.

Each process-cooling unit was provided with an adjustable suction pressure regulating valve, as indicated in the sketch. These valves could be adjusted to maintain any desired evaporating pressure on the processing unit.

Analysis of the plant's operating procedure disclosed that the three compressors were being operated independently, one on each cooling unit, and that secondly, the suction pressure regulating valve was so adjusted as to hold the evaporating pressure at 10-lb gage.

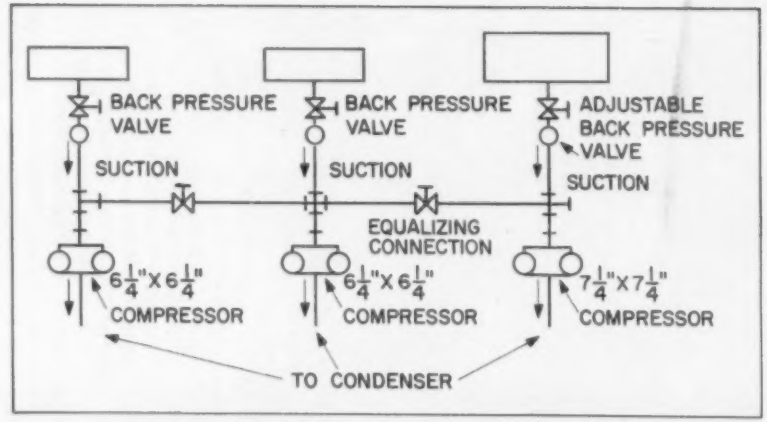
Since the capacity of the three compressors was considerably in excess of the actual cooling demands, there occurred a decided drop in suction pressure on the down stream side of the regulating valve on each process-cooling unit, with the result that the compressors were actually operating at 5-lb inlet pressure. Actual required capacity to handle the production cooling plus losses was 33½ tons, very nearly.

At 10-lb suction pressure and 185-lb condensing pressure, the combined capacity of the three compressors at the speed at which they were being operated was 46 tons refrigeration, while at the same speed and condensing pressure and 15-lb suction pressure, the combined compressor capacity was 56 tons.

Since the suction lines to each compressor were short, about 25 feet, the pressure loss would not be a factor of importance, and since the evaporating temperature of the refrigerant would be low enough to give the required heat head between the boiling refrigerant and

*Consulting Engineer

fold along this line—outside edges toward you



About 70 per cent of total installed motor hp was required by the refrigerating plant. Arrangement, as shown here, made possible operating each processing unit independently, or all handled as a group. Adjustable suction pressure regulating valves made possible any desired evaporating pressure on units

medium being cooled, it is evident that one source of high power cost in this plant was low suction pressure.

Actually, one of the 6¼ by 6¼ compressors and the 7¼ by 7¼ compressor were ample to the cooling demands; therefore it was possible to shut down one 30-hp motor.

Water for cooling the jackets of all three compressors was taken from the basin of the evaporative condenser which contained not only wind-blown particles of sand and clay, but also the water was largely saturated with soluble solids thrown down as a result of evaporation of the spray water.

Since the compressor jackets had not been drained and cleaned in many months, they were badly plugged, thereby reducing the amount of water circulated well below the required quantity. This in turn resulted in overheated jackets, interfered with normal lubrication, and finally, caused high superheating of the entering suction gas, thereby reducing compressor capacity.

It is well known that the capacity of a refrigerating machine depends upon the weight of gas handled per unit of time; it follows then that as the gas is superheated, its weight per cubic foot is reduced, causing a reduction in compressor capacity.

Still another source of loss in compressor capacity and cause of high power bills was non-insulated low temperature suction lines and non-insulated low temperature suction gas liquid accumulators. Because of lack of insulation, a great amount of suction gas superheating occurred eight hours a day, five days a week.

Finally, operating practice in this plant had for years been most wasteful. For example, it was the practice to start all three compressors at the beginning of the work day and allow them to remain in service all day regardless of the weight of material being processed.

All of the above shortcomings are now being remedied.

Want Extra Pages of Articles?

No need to tear up your copy of POWER ENGINEERING. We'll be glad to furnish you extra pages of articles. Just write the Editor on your letterhead or use the enclosed post card, and jot down the title that interested you.

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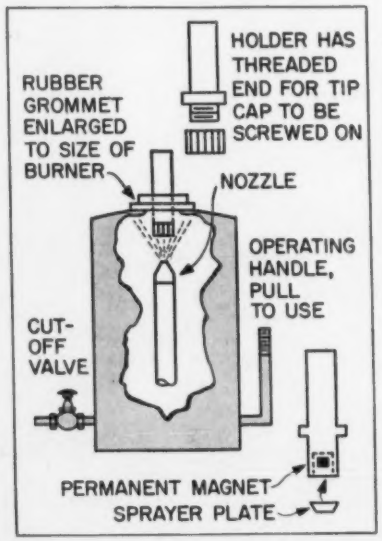
cut along this line

Ever Try This Way of Cleaning Burner Tips?

By CARROLL T. HEBERT


HOLDER HAS THREADED END FOR TIP CAP TO BE SCREWED ON
RUBBER GROMMET ENLARGED TO SIZE OF BURNER
NOZZLE
OPERATING HANDLE, PULL TO USE
CUT-OFF VALVE
PERMANENT MAGNET
SPRAYER PLATE

AN EFFICIENT burner tip cleaner can be made from a spark plug cleaner of the type used in the automotive industry. We chose the kind that provides sand-blasting cleaning only and omits electric testing. Very little has to be done to adapt it for use on burner tips.

In the machine shop, two holders — one for the tip cap and one for the sprayer plate — can be fashioned out of aluminum, for light weight and ease of handling.

As the sketches show, use of the holder with cap screwed on permits the cap to be inserted well into the sand-blasting unit. Flange seated against rubber grommet prevents leakage.

Holder with mild strength magnet recessed in hole can be used for holding sprayer plate in position. Plate can be cleaned readily.

We have found this method to be faster than cleaning by scraping or wire brushing; also, it eliminates the chance of damaging the burner tip.

Cleaner shown with holder and tip cap inserted into unit in sand stream. Cut-off valve connects the cleaner with the plant's service-air system

Time Switch Prevents Motor Moisture Trouble

By HENRY JOSEPHS*

BECAUSE of its proximity to the river and the ever-present moisture, one of our long machine shops had a recurring problem: dampness grounded out the direct-current compound wound motors on the numerous machine tools used in the work.

During daytime working hours, when the lathes, millers, etc, were in use, the heat developed in the motors kept them and their windings dry. But the trouble developed when the machines were shut down for the night and the moisture crept in.

The problem was solved by using a time switch on each machine, which threw the shunt field across the line an hour after quitting time, and disconnected it an hour before the day shift machinists arrived. This practice has worked out very well.

The shunt fields are of high resistance and thus draw little current. But, circulating through the winding the night through, the heat developed keeps each motor thoroughly dry and free from premature grounding.

The time switches are also set to control the current to the motors on the one day a week when the shop is shut down.

*Maintenance Superintendent, Sun Shipbuilding Corp, Chester, Penna

fold along this line—outside edges toward you

Fig. 1. These ready-made, adhesive-backed markers will simplify the pipe identification problem

Fig. 2. Letters and numerals come in various sizes, are black on yellow, cost about ½ cent each

How We Solved the Pipe-Marking Problem

By RICHARD P. HARRIS

ADEQUATE IDENTIFICATION of pipes and valves has long been a problem, not only in power plants but also in many other industrial establishments. Various marking systems have been developed in different plants. Then committees have set up industry-wide or nation-wide codes for standard markings. These, in turn, have been changed from time to time.

One method has been to paint the pipes different colors. This left something to be desired, so it was elaborated by painting various colored stripes around the pipe at each valve or tee and at stated intervals the full length of the pipe. Then the problem was to be sure that an excited man, under the stress of emergency conditions, would not forget what the markings meant.

In a steam power plant such as ours, however, this system has serious deficiencies. It is important to know not only what is flowing in the pipe, but also the direction of flow, the origin of the flow, and the destination. Color of the pipe may indicate steam, but is it high pressure or low pressure, is it to emergency oil pump or to steam traps?

Other plants, faced with this same problem, may be interested to hear how we have solved it at the Provo City (Utah) Municipal Power Plant. The system described here was worked out by the writer under the supervision of Wendell A. Christensen, plant manager, with the coöperation of Jack H. Strong, maintenance engineer, and Robert A. Wiley, maintenance foreman.

Basis of the whole system is the use of ready-made, adhesive-backed pipe markers. These are available with a wide variety of legends in several sizes and a number of background colors. Hi-Press Steam, Condensate, City Water, Pond Water, are a few of the labels we have found useful. Usually used in connection with these are arrows indicating the direction of flow. Double-ended arrows indicate that the flow may be reversed under certain conditions. These are placed on the pipe at each valve and any other place where pipe identification might be helpful. Application is easy, as the marker needs only to be peeled from a card and applied to the pipe.

The feature of our system, however, that has been most helpful in routine operation and almost a life-saver in emergencies, is the use of adhesive-backed letters and numerals. With these we can eliminate the necessity of tracing out pipe lines, and reduce to a minimum the probability of operating the wrong valve. We add to the markers such legends as, From No. 2 B. F. Pump, To Deaerator, To Building Heating System.

These letters and numbers come in various sizes. The ones we use most frequently are ¾-in. high, with black letters on a yellow background. They cost about half a cent each, depending on the quantity purchased. The com-

plete markers range from ¾ of a cent to about 16 cents each, depending on the size. Any desired label can be made to order, at a slightly higher cost.

One who is thoroughly familiar with all pipes and valves should apply the markings or closely supervise the job. In our plant all employees have been asked to report any errors they notice and also to make suggestions of places where markers are needed.

We also use this system for classifying and identifying switches and other electrical equipment. For most marking purposes we much prefer it to stencils, as there is no stencil to make up, no paint to mix, no brush and other equipment to clean. The saving of a man's time thus more than pays the small cost of the markers. And when a pump or other piece of equipment fails and a man has to run to a valve, these markers are like a sign post at the fork of a desert road.

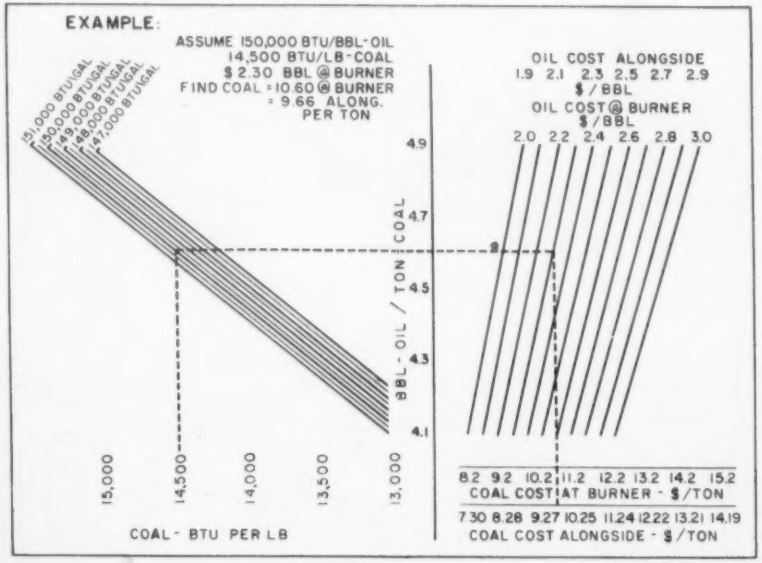
Editor's note: For more information about these markers, write The Editor, POWER ENGINEERING, Or jot down Pipe Markers on the postcard inserted in this issue.

Quick Way to Determine Most Economical Fuel

By RAYMOND A. ROUSSEAU

Power Services Engineer, New Bedford Gas & Edison Light Co, Mass.

IN PUBLIC UTILITIES, as well as many other industries, it is often necessary to be able to determine readily the most economical fuel for power generation. The accompanying nomogram which we have worked out may be of value to other readers of the Handbook.



Alongside prices will vary with each plant, but scales suggest what you can do to make complete chart

I have included on the nomogram an example for coal. Of course, it can be used in reverse to find any other variable provided three of the four are known. It will be noted that there are four cost scales. Our oil cost alongside is $0.10 less per bbl than the cost at the burner. This is our calculated cost of oil heating, air preheater maintenance, and for handling.

The same is evident for coal. The difference includes $0.79 for pulverizing, maintenance and handling, and 1½ per cent of the intermediate figure or balance. This is also deducted to cover losses while coal is in open storage (wind losses). It is realized that the alongside prices will vary with each plant according to the costs involved; but the scales were left in here to serve as a guide or inspiration to others who might like to work up their own scales to obtain a chart as complete as this one.

This nomogram has been a tremendous time-saver for us.

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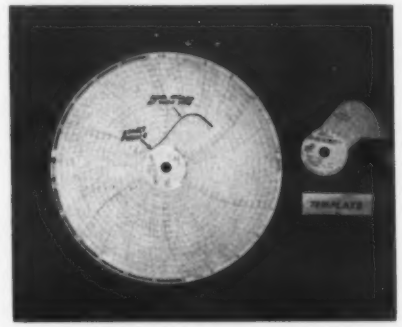

How to Make a Template for Bringing Boilers Up to Pressure

By EDWARD SWITOW*

Plot the pressure-pickup curve on the chart from zero to full boiler pressure. Cut out template

IF you've been bothered by the problem of figuring how long it takes to have a particular boiler in the plant up to operating pressure, in order to roll the turbine for start-up, then here is a simple tool which will eliminate much estimating.

The only information needed is a curve of pressure raise from zero pressure to full boiler pressure versus time for the particular boiler in question.

Using a circular chart of the kind used in the boiler pressure recording meter, plot the pressure pick-up curve on the chart from zero to full boiler pressure. Cut out this template, as shown in the photograph, mark the time in hours necessary for correct pressure raise, and mount the template on a piece of hard cardboard.

If boiler pressure is to be raised on a cold boiler, and the time of the equired minimum turbine rolling pressure is known, simply lay the template on a circular boiler pressure recording chart, with the required rolling pressure on the template intersecting the required rolling pressure on the chart at the time for start of roll.

Next step is to draw a curve on the chart. The operator will now have a pressure raising curve which will show him at what time to start firing, a definite curve to follow, and what time the boiler will have reached full operating pressure.

This template can also be used to show at what time to start firing a boiler that is still under some pressure, by correctly positioning the template on the boiler recorder chart that is being used for recording the pressure loss in the unfired boiler.

We have found this template very useful, simple to make, and simple enough for any operator to use.

* Engineer, Paddys Run Station, Louisville Gas and Electric Co, Ky

cut along this line

Proved 10,000 times the world over

POWELL
PRESSURE SEAL
VALVES
Fig. 16031—New, steel pressure seal "Y" globe valve for 600 pounds.
Fig. 11365—Steel pressure seal horizontal lift check valve for 1500 pounds. Piston guided disc.
Fig. 19003—Steel pressure seal gate valve for 900 pounds.

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More than 10,000 Powell Steel Pressure Seal Valves are now in use all over the world—indisputable evidence they are meeting the challenge of modern industry to control constantly higher pressures at elevated temperatures. These quality, precision-built, precision tested, leak-proof valves, with exclusive features of design and construction, are available in gate, globe, angle, check patterns for 600 to 2500 W.P. and special working pressures. Many are in stock for quick delivery. Contact your nearby Powell distributor—or write directly to us.

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For more data circle 540 on Post Card

Finding Humidity That Prevents Condensation

By JOHN D. CONSTANCE, P.E.

OPPOSITE IS A USEFUL CHART which gives quick answers to questions on permissible relative humidities to prevent condensation, and many other questions on atmospheric condensation.

Precision machine parts are usually processed under controlled conditions of atmosphere; their handling or storage under different conditions may cause surface condensation. Control and prevention of moisture condensation in plant air systems may be quickly determined with the help of this chart. General ventilation problems may be solved to prevent condensation on machinery that has been in cold areas for long periods of time and then brought out.

Example: Goods are to be removed from storage in a 42 F room to another room at about 60 F. What relative humidity must be maintained so as to avoid condensation on surface of goods?

Answer: See chart and read 50 per cent.

Example: Plant air has been cooled to 40 F saturated. Line runs out into plant yard and is exposed to wintry temperatures. Will condensation take place in the pipeline?

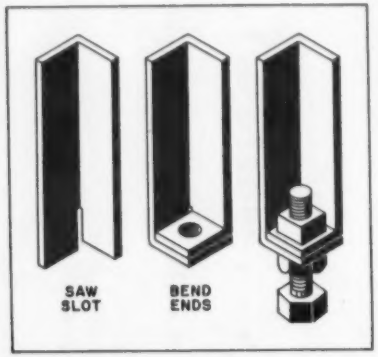
Answer: At 40 F on left side of scale, run across right to 100 per cent relative humidity. Read down to 40 F. This is the point where condensation takes place and any temperature below 40 F water will condense out. Below 32 F the condensed water freezes, plugs the line.

Example: A piece of heavy metal machinery is taken indoors after standing out in the open during cold weather (35 F). Temperature indoors is 60 F. What is the permissible relative humidity to prevent surface condensation on the metal parts?

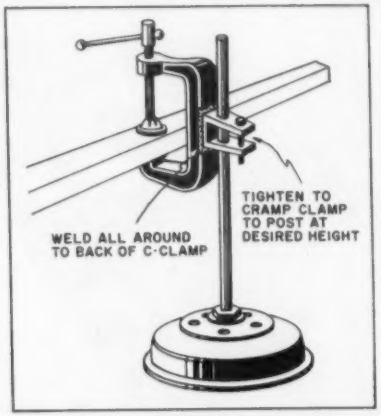
Answer: From chart read 39 per cent.

Try These Useful Shop Tricks

By CHARLES H. WILLEY

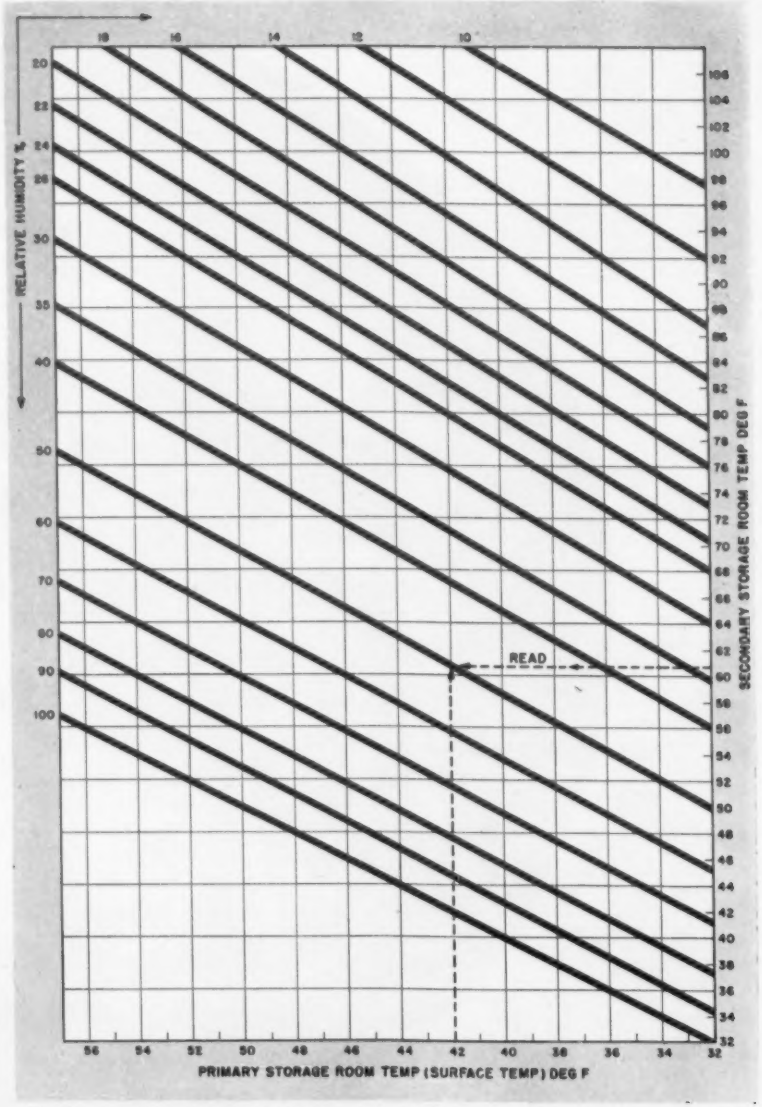


To make angle iron legs adjustable (handy idea if you have a work bench or other stand on legs like this): saw a slot in each leg, making one a little shorter than the other. After slotting, bend the cut ends, as shown in the sketch, and use a bolt and nuts in the manner shown, the top nut being square. Leveling is then a simple matter



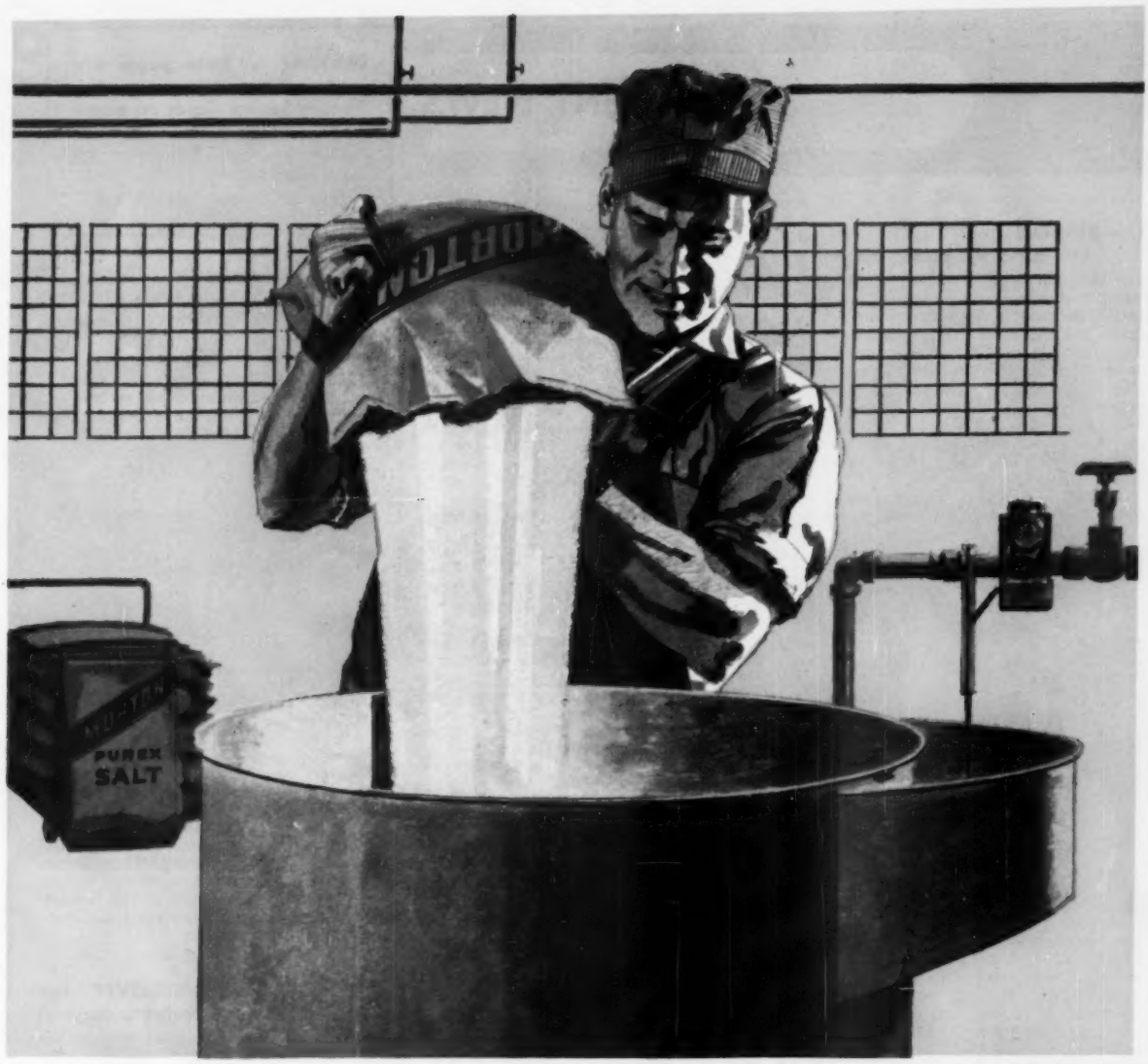
Handy holder for shop work can be made by using a large-sized C-clamp with a pinch U-shaped piece welded to its back. A brake drum base will give the holder mobility. It's useful for many jobs, at the bench or floor and is adaptable to weld work

fold along this line—outside edges toward you



This chart provides a quick way to find permissible relative humidities that will prevent condensation

cut along this line



This brine tank never needs cleaning out

With 100% soluble Morton Purex Salt you never have an accumulation of insolubles: no encrustation, no sediment buildup in brine storage chambers. For Purex Salt is guaranteed to have both a minimum purity of 99.5% sodium chloride and to be free of insoluble matter than can settle out in brinemaking systems. You'll find Purex ideal for producing a fully saturated, high clarity brine at highest possible flow rates.

Produced in the economical vacuum pan system, Morton Purex Salt has a controlled granulation best suited for automatic brinemaking and brine storage installations. It dissolves rapidly and uniformly, giving particularly fast flow rates of saturated brine where the water flows through a salt bed, as in automatic brinemaking units.

Available in bags and bulk carloads, Purex can be used in bulk wet storage systems and in Morton Model E Series Brinemakers.

For more information about Morton Purex Salt and for free expert help on any water softening or brinemaking problem, write or wire:

Beat Heat Fatigue by taking Morton Yellow Salt Tablets. They give fast relief without causing nausea or stomach upset. Available with heavy duty disposable dispensers.

MORTON SALT COMPANY

INDUSTRIAL DIVISION

Dept. PE-4, 110 No. Wacker Drive, Chicago 6, Illinois

For more data circle 541 on Post Card

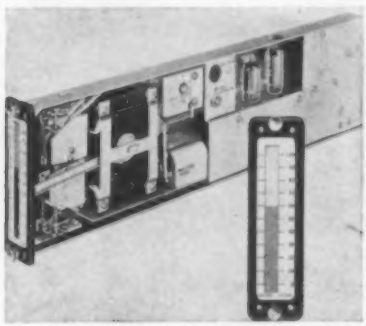
EQUIPMENT NEWS

Described on these pages are new and improved products. Use Reader Service Cards on pages 117–118 to ask for more information on them. Just circle the item numbers of all the products in which you are interested.

1 — RIBBON INDICATOR fits a 1⅛-by-5 in. panel opening

The A22M, an electronic ribbon indicator, measures only 2 in. by $5\frac{3}{16}$ in., and is for use in regular panels where space is limited, or in graphic panel installations. It can be mounted vertically, or in a left or right horizontal position. The A22M is a high-amplification, null-balance device operating on the common 0–0.5 v a-c signal with accuracy of ± 1 per cent of full signal input and can be supplied with one (high or low) or two alarm contacts.

Design is simple. The ribbon-drive mechanism and amplifier are mounted



on the main chassis. For convenience, the amplifier assembly is a self-contained unit that may be removed. Only zero and span adjustments are necessary and these can be made from the front of the panel. A magnetic switch linked to the connector lock in the mounting frame disconnects power from the unit before the cable connector can be removed, it is noted, making the A22M suitable for use in Division 2 areas. Specification Sheet A808 gives details. Swartwout Div., Crane Co.

2 — RADIO SYSTEM indicates, identifies power outage

This remote alarm indicator radio system is designed to indicate and automatically identify a power outage or emergency condition along a utility or service network. The system includes sending units at strategic points along a power line and a digital decoder-printer (shown) at a central radio receiving station which decodes and records the alarm signals. The system, which can utilize the base station of any 25–50 or 150–174 mc two-way mobile radio system, is announced as enabling monitoring of 290 individual remote, unattended points.

The remote alarm transmitter unit, mounted in a pressurized 3-kv transformer tank, includes a 25-w radio transmitter, tone coding device, and omnidirectional antenna. When triggered by an actuator switch, if a circuit breaker opens, for example, the unit automatically generates and transmits a tone signal, it is explained; the central radio base

station receives the signal and feeds it to the transistorized digital decoder. Translated into a specific code number, the signal is printed on a paper tape. A visual alarm light or other alerting signal is also activated. The sender unit repeats the 3-sec alarm five times over a 5-min period. Motorola Inc.

3 — OVERSPEED MONITOR protects steam turbines

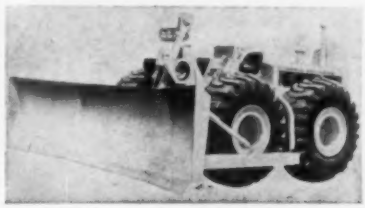
Type FDW Overspeed Monitor is designed for accurate and fast protection of steam turbines from excessive speeds. If in the case of turbo-generators the load is suddenly greatly reduced or dropped altogether, an inadmissible increase in speed calls for a suitable protective device. The responsive time of Type FDW is claimed to meet these requirements. Monitor employs a tacho-generator which is directly coupled to turbine shaft and delivers an a-c voltage whose frequency is proportional to rpm it follows without inertia. Generator is selected to produce 600 cps at turbine speeds of 3000 rpm. A discriminator changes frequency derived from overspeed monitor into proportional voltage. After differentiation, d-c voltage is obtained which represents speed rate of change. If this exceeds a given limit, then an electronic circuit makes normally-closed relay drop. Relay contacts that may be connected as desired and form output signal serve to excite magnet type valves or similar devices. Rohde & Schwarz Sales Co.

4 — NYLON TUBING for the high pressure fluid services

Now available in a wide variety of diameters and wall thicknesses on an "off-the-shelf" basis, this nylon pressure tubing is designed for applications in high pressure fluid and pneumatic service, and in "push-pull" applications where friction is a problem and lubrication impossible or impractical. Continuous lengths of nylon tubing from a minimum of 0.010 by 0.060 in. to a maximum of 0.280 by 0.500 in. available. Applications for the tubing include flexible cable casing, heater and vent control cable casing, wire cladding and fluid conductors. The Garlock Packing Co.

5 — COAL BLADE lets tractor handle bigger load

For use with company's Model C Tournatractor, the U Blade is claimed to handle about 50 per cent more material than a conventional dozer blade. It measures 15 ft from end bit to end bit and is 4½ ft high — 3 ft wider and over 1 ft higher than usual. The added size



and curvature of this blade causes the coal to keep a live rolling action ahead of the machine, reducing normal resistance encountered in coal handling. Manufacturer says that, in a straight line comparison, it can push between 6 and 12 tons as compared with 4 to 7 tons with a conventional dozer blade over the same distance. As an optional accessory for the Model C Tournatractor — a 218-hp tractor capable of speeds to 17 mph — the U Blade can be factory installed or customer installed. LeTourneau-Westinghouse Co.

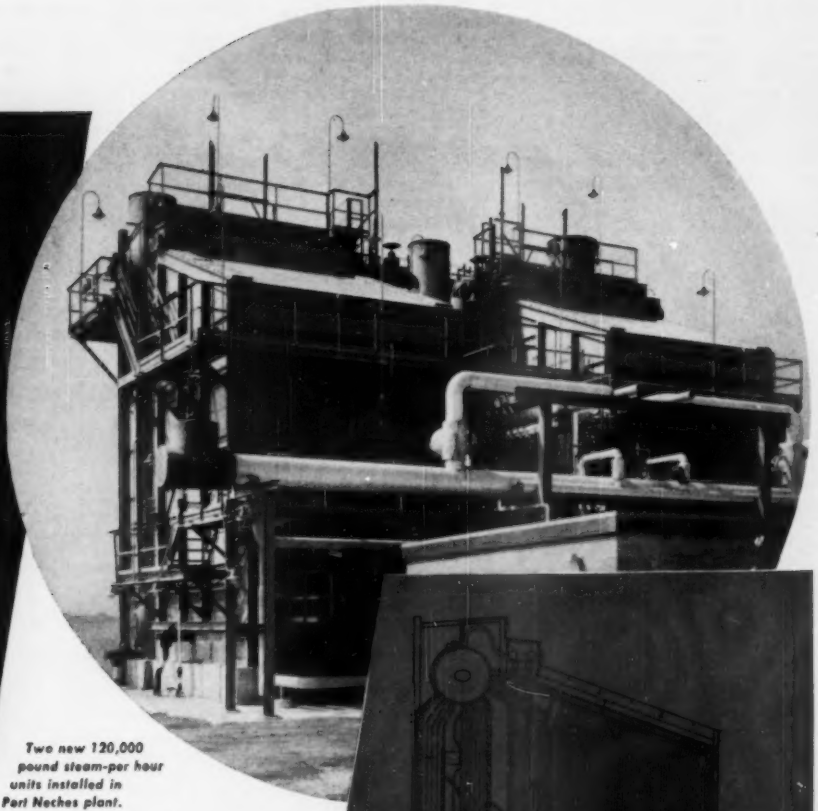
6 — TRANSMITTER-RECEIVER for remote temp control

Applications of this transmitter-receiver system include both heating-cooling-air conditioning and industrial processes, especially when remote control is involved. Series 200 Transmitter transduces a temperature measurement into a 3- to 15-psi air pressure from a remote location. Signal may be sent to a receiver gage which continually indicates temperature measurement. Transmitter may also serve as a sensor for remotely located receiver-controller. Operating in conjunction with transmitter, Series 200 Receiver-Controller maintains a selected temperature at a remote location. Bulletins 371, 371-1 and 371-2 give details. The Powers Regulator Co.

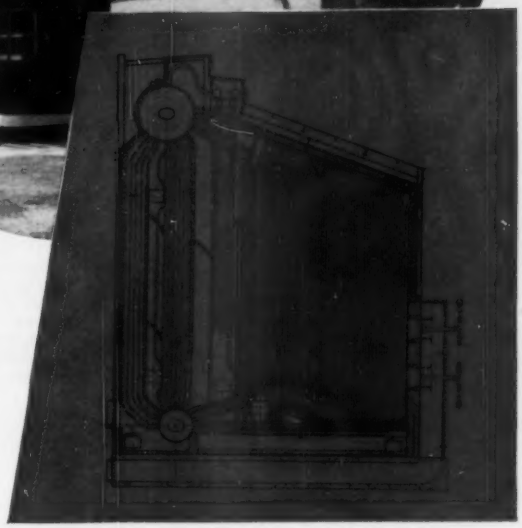
7 — AUTOMATIC CHARGERS serve all types of batteries

These automatic battery chargers are designed for lead acid, nickel cadmium, silver zinc, silver cadmium and Edison batteries. Units employ silicon power rectifiers, and for stability and reliability silicon diodes in the control circuit. The units use only static control — there are no moving parts, relays or tubes — and are cooled by natural draft without use of fan. Standard line includes models ranging from 6 to 120 v, 0–125 amp output. Close end voltage regulation (±1

Steam for Jefferson Chemical by Vogt



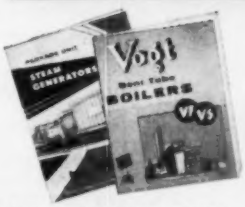
Two new 120,000 pound steam-per hour units installed in Port Neches plant.



The needed additional power and process steam capacity for Jefferson Chemical's expanded Port Neches plant is furnished by the two Vogt boilers pictured here, each with a capacity of 120,000 pounds per hour. The boilers are designed for 675 lbs. pressure to operate at 625 lbs. pressure and 769°F. total temperature. The furnaces are equipped with gas burners and have water cooled front and side walls.

Bulletins describing Vogt boiler installations in a variety of industrial plants for power, processing and heating are available on request.

Installation by C. F. Braun and Co., Engineers.



For Custom Installation Bulletin VF-VS-2 • Package Unit Bulletin PSG-3, address Dept. 24A-BPE.

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STEAM GENERATORS

Vogt

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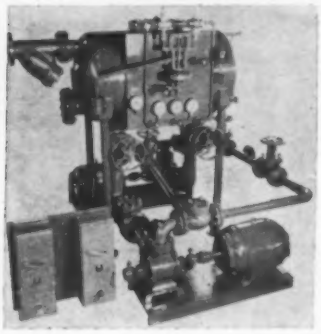
per cent) is maintained for a change in a-c line voltage of (±10 per cent). Current limiting holds charging current within safe value, company says. Moving coil type d-c voltmeter and ammeter are standard. Christie Electric Corp.

8 — A-C VOLTMETER is more accurate, easier to read

Improved readability and a 40 per cent increase in accuracy are claimed for this narrow range a-c voltmeter. Calibrated from 110 to 130 v, the instrument is intended for application where holding voltage to a high degree of accuracy is required. High readability is attributed to the dial, calibrated in ½-v intervals, which is combined with nearly linear spacing throughout the full scale. With accuracy increased from 0.5 to 0.3 per cent of midscale value, the new meter is said to provide readings accurate to within ±0.36 v. It uses a milliammeter element fed by a Zener diode circuit, which spreads 110-130 v over 95 per cent of the scale length. It is available for both 50/60 and 400 cycle duty, has a 2-sec response time. Two flange dimensions may be had: 4¼ in. (7.1-in. scale length) and 8¾ in. (14.2-in. scale). General Electric Co.

9 — BOILER RETURN SYSTEM saves both fuel and steam

The Duplex Boiler Return System is designed to save fuel and steam, while permitting high pressure boilers and steam processing units to operate at top efficiency. It automatically maintains a positive differential between steam supply and return lines, says manufacturer, and as a result, condensate and air are quickly evacuated from steam line, permitting processing units to operate continually at full



capacity. Steam requirements are reduced because condensate is returned to boiler usually within 10 deg of temperature of saturated steam.

This is a closed system, consisting of receiver tank for condensate, two 2-stage pumps, differential valve, piping and remote electrical control panel. It is explained that both pumps operate when processing units are started. At a predetermined pressure, one pump automatically cuts off and the other maintains discharge pressure necessary to return condensate directly to boilers. Differential valve serves to automatically admit correct amount of steam to receiver, and maintain required differential. System is built in ten sizes with a boiler capacity from 100 to 2,000 hp. Stickle Steam Specialties Co.

10 — DIGITAL COMPUTER for process control, and data processing

Developed jointly by Leeds & Northrup Co. and Philco Corp., the LN-3000 Digital Computer is described as part of a system for process control and data processing in electric power, metals, chemical and other industries. Fully transistorized, this compact computer and its associated input-output apparatus occupies the floor space of a pair of

four-drawer letter files. It is a general purpose, serial, internal binary fixed-point, stored program computer, handling all information internally as binary numbers, one bit at a time, with input and output in ordinary numbers.

It has three general "on-line" functions. When used for on-line data reduction and calculation of operating guides, the system of which the computer is part will provide an "open loop" control — receiving electrical signals or inputs representing temperatures, pressures, flows etc., and solving algebraic relationships existing between these conditions. The result of these calculations produces operating guides which may take the form of heat rates or efficiencies.

In program control service, the computer may be used to make complex series of yes-or-no decisions, as in process start-up or shut-down. This service may be used for automatic program control or for information of operating personnel. A third type of service for the equipment is supervisory computer control, in which it "master minds" information for the control. The computer calculates settings for the analog controllers on the basis of known process equations, or it may be programmed to develop them. This type of control may also be expanded to include program control for automatic start-up or shut-down. In addition to on-line services, the computer may be used for off-line calculations. Leeds & Northrup Co.

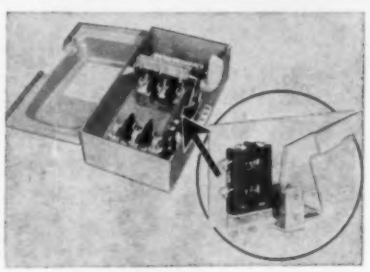
11 — PULLEYS are economical variable speed units

This economical variable speed pulley is suggested for low-cost replacement on existing equipment. The series consists of five sizes ranging from fractional to 1 hp, with speed ratios to 2.8 to 1. Features announced include easy installation, adjustment over a wide range of speeds, curved pulley faces for full belt contact, high ratio for small face diameter, positive lubrication and compact, lightweight construction. Lovejoy Flexible Coupling Co.

12 — CHEMICAL CONTROL for cooling towers

For feeding balanced chemical treatment into circulating water systems of cooling towers and evaporative condensers, the Chemicator is a small, lightweight, closed reservoir through which a portion of the recirculating water flows. It is mounted on the side of the equipment, and on its upper portion a sleeve holds a weather-sealed plastic tube containing a sequence of variously formulated compressed chemical briquettes. These are made of polyphosphates and organic chelates to remove and prevent scale formation, together with automatic pH, algae and slime controls. As the briquettes are gravity-fed into the water flowing through the reservoir, they slowly dissolve and are carried into the system.

It is pointed out that the Chemicator has no moving parts yet feeds chemicals in precise amounts; the flow of the recirculating water controls the system. Chemicals are fed only when the pump is in operation, and as needed. The Chemicator sells for around $20.00 to users of company's briquettes, and an installation is said to average around $5.00. The briquettes are custom formulated and packaged in combinations to combat water problems of any geographical area. Erlen Products Co.



13 — INTERLOCK KIT for heavy-duty safety switches

This electrical interlock kit permits field installation of additional contacts in safety switches. Because the interlock contacts make or break ahead of main switch blades, the interlock can be used within control circuits. Available for all of company's heavy-duty safety switches, interlocks are supplied with one normally-open and one normally-closed contact. Interlock assembly is actuated by handle of safety switch. Cost savings result from use of three-pole switches from stock rather than special-order four-pole switches, it is pointed out. Square D Co.

14 — LEVEL CONTROLS for use with problem liquids

NM-1 and NM-2 Magnetrols are low-cost liquid level controls in which all parts in contact with liquids or vapors are non-metallic; they are suggested for use with liquids that present problems in handling. Polyvinyl chloride is the non-metallic material used. Among advantages announced are immunity to galvanic or electrolytic attack and to oxidizing agents; corrosion resistance; smooth surface to discourage any tendency to scale or act as host for deposits. Also, it is noted, these controls do not contaminate or impart odors or tastes to the liquid. Safety in handling inflam-

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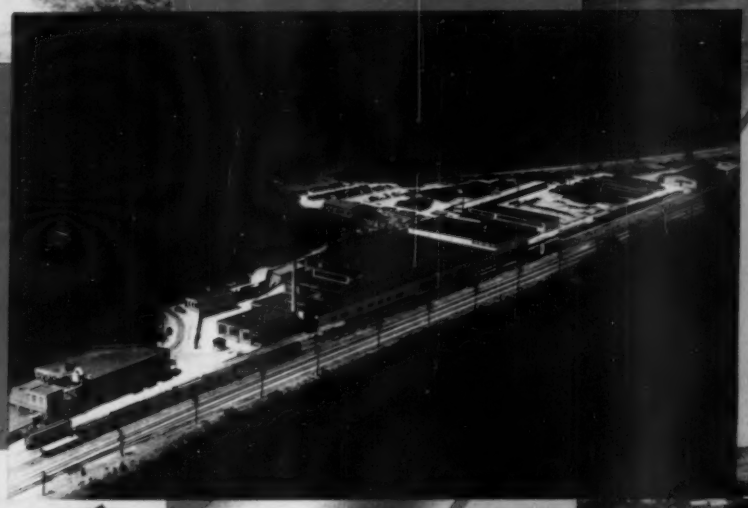
1938 . . . Two story plant located on Brown Street in Barberton, Ohio

1960 . . . Present plant site in Barberton covers 10½ acres with 11 buildings.



1956 . . . Establishment of Ric-wil Company of Canada, Ltd. St. Thomas, Ontario

1939 . . . Establishment of Western Ric-wil Company, Newark, California

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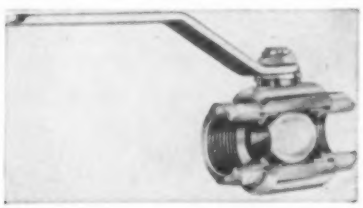
mable and explosive liquids, as well as in volatile fume areas, is another advantage, manufacturer states, due to non-inflammable, non-sparking materials.

The controls are for use with liquids of specific gravity of 0.70 or above. Chamber and float construction are for service at 100 psi at 70 F, or 50 psi at 140 F. Model NM-1 Magnetrol is an external float cage unit with a sealed body and float totally enclosed. Model NM-2 is a flanged style chamber unit. Magnetrol, Inc.

15 — BALL VALVES offer cost cutting features

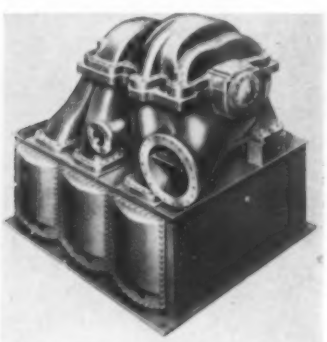
Designed to reduce initial in-place cost and valve maintenance cost, the McCannaseal and the McCannaflo (shown) Ball Valves provide the full flow of a



gate valve, the tight shut-off of a globe or needle valve, company says, and the quick quarter turn of the plug valve. Valve design permits temperatures up to 350 F and pressures to 700 psi for the McCannaseal and up to 1,000 psi for the McCannaflo. They are constructed to handle practically all fluids, semi-solids, compressed gases, and compressed air. Pressure may be applied from either side, and the greater the pressure the tighter the seal. Standard body metals include stainless steel, cast steel, ductile iron, cast iron or bronze. Valve balls are chrome-plated carbon steel, bronze or stainless. Sizes range from ¼ to 6 in., screwed or flanged end connections. Hills-McCanna Co.

16 — AIR COMPRESSOR for industrial, other applications

Multi-stage centrifugal air compressors in this company's Type H line are designed to furnish "100-lb" air for oxygen plants, centralized air systems and other air applications. The series of 110-psi units features integral intercoolers between each stage of compression for high efficiency. Six case sizes range from



1000 to 8000 bhp, capacities from 5000 to 38,000 cfm. Each unit comes as a complete package including matching driver, intercoolers and lubricating system. Efficiency of the Type H is attributed to the intercooling system and to volute and impeller design. Clark Bros. Co.

17 — SUCTION PUMP for solids handling services

The Model 12B2, a 2-in. suction and discharge unit, is an addition to company's self-priming centrifugal solids handling pumps. It features impeller design permitting passing of spherical solids up to 1⅛ in. diam. It mounts high and dry, with only the suction in the sump. It incorporates removable endplate for quick inspection and maintenance. Wearplate is renewable. Capacities range from 40 to 220 gpm. Other sizes available are: 3, 4 and 6 in. The Gorman-Rupp Co.

18 — CONVERSION UNITS for electrostatic precipitators

For use in high voltage d-c power supplies on electrostatic precipitators that collect fly ash and dust particles, these silicon rectifier conversion units are similar in size and shape to high-voltage vacuum rectifier tubes. They consist of silicon rectifier diodes immersed in oil and enclosed in an insulating cylinder. When used to replace vacuum tubes, they are plugged directly

into existing tube sockets. Requiring no filament power, they are said to provide higher operating efficiencies while eliminating frequent tube replacement. When used to replace mechanical rectifiers, the silicon units are claimed to reduce operating and maintenance costs and to eliminate the ozone, vibration and noise created by operation of the motor driven rectifier switch.

Manufacturer states that cost savings from tube replacements and inefficiencies pay for the initial cost of these conversion units within a relatively short time — depending on present tube replacement requirements. The units are available for use with rectifier transformers rated up to 75,000 v RMS, and to 45 kva in full wave bridge rectifier circuits. General Electric Co.

19 — DIESEL FUEL ADDITIVE promotes cleaner combustion

This fuel additive is formulated as a detergent, dispersant and solvent to aid in eliminating and preventing sludge formations, gum and varnish in the fuel supply line. Its penetrating action is said to aid in keeping injectors and moving parts clean, to provide more complete, cleaner combustion and better starting. The Shaler Co.

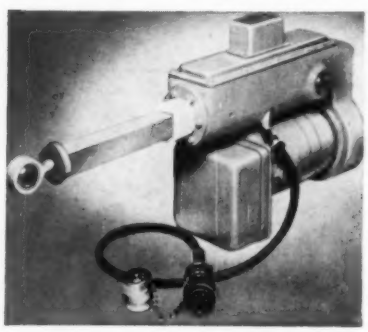
20 — BALL TYPE INDICATOR for very low flows

For flows down to 0.075 gpm (water) and ½ cfm (air or gas), this indicator is designed to show at a glance whether flow is taking place. Said to be clearly visible from a distance, even in bad

light, the flow makes the ball dance in the toughened glass dome. If flow stops, ball drops out of sight. It is useful in applications such as air, steam, water, and oil purge lines to instruments and mechanical seals; cooling water to compressors, condensers, jacketed process vessels, laboratory equipment, and electronic equipment; lubricating oil to bearings, and others. Indicator is made in ¼-in. pipe for pressures to 100 psi with die-cast bronze body, and nylon or Teflon ball. McIntosh Equipment Corp.

21 — LINEAR ACTUATOR for industrial use

Model 499B is a heavy-duty electrically-driven linear actuator suitable for use wherever open-loop positioning is required. It can move up to ¾ ton, company says, and can hold 1½ tons. A



brake is used to reduce overcast to a minimum. Stroke of Model 499B is continuously adjustable from 4.25 to 5.25 in. A second version — Model 499B-1 — offers a shorter stroke of from 2.75 to 3.75 in. Model 499B is powered by a single-phase 115-v, 60-cycle motor capable of developing 0.14 hp at 5000 rpm. A significant advantage is that it is a self-contained unit requiring only line current for instant operation. Lear, Inc.

22 — NON-SLIP SURFACING makes floors glow in the dark

An extra safety feature is available in X-L Veneer, a non-slip floor surface. In addition to its regular colors of red, green and gray, this topping can now be had in a luminous yellow that glows in the dark. X-L Veneer contains an

sharp

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American Bi-Metal Thermometers are made of weather-proof stainless steel. All joints are welded to solid unity, then polished smooth so corrosion won't build up and destroy the thermometer's usefulness. And, you don't have to discard this thermometer even if the glass is ever broken. The bayonet lock bezel makes replacement easy.

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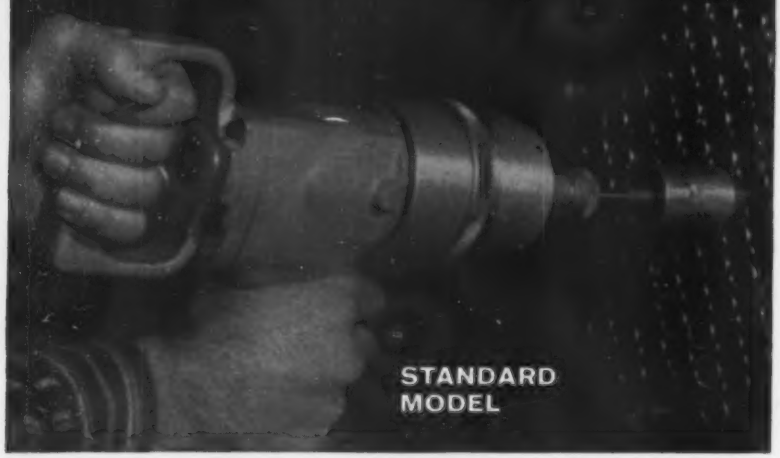
ELLIOTT air magnetic tube expander drives

automatically controlled for fast, accurate tube rolling



Designed for *faster*, precision tube rolling, the standard model Elliott Air-Magnetic drive is setting new records for speed and accuracy. Some operators average 12 tubes per minute. Desired torque easily preset by rotating forward end of unit. No tools needed. Rolling stops when preset torque levels are reached. Includes trigger-controlled, explosion-proof air motor in single unit. Magnetic control, no springs. Balanced for easy handling. For tubes ¼ in. through 3 in. *Standard model* handles most jobs. *Heavy-duty* for higher torque.

ALSO Electric Control ... Tube Expanders ... and Related Accessories

Elliott offers the Automatic Electric Control—an accurate torque-limiting device designed for tube expanding with any standard tapping motor. Also, a complete line of tube expanders, with rotating, parallel, self-feeding rolls. Available in 4 sizes, ranging from ¼ in. to 3½ in. O.D.

Other related accessories include Elliott tube gage, tube plugs, tube pilot, and tube rolling lubricant.

Write for descriptive literature *today*.

Y9-3

ELLIOTT Company
LAGONDA PLANT, Springfield, Ohio

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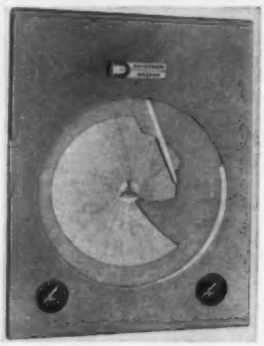
abrasive filler and aggregate combined with synthetic, heavy-bodied plastic base material and solvents. It can be used over concrete, wood, steel, tile or terrazo, manufacturer points out, and, in the luminous yellow, is especially suited for dark steps, ramps and depressions. The Monroe Co., Inc.

23 — PNEUMATIC TRANSMITTER has interchangeable cams

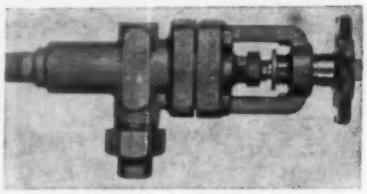
Model 7002 is announced as a pneumatic program transmitter with interchangeable cams offering a choice of 1-, 8-, 12-, 24-hr and 7-day cam drives. The programmer handles one or two transmis-



sion systems, transmits a 3-15 psi pneumatic signal, and can be used with single or double cams. The transmitter features sturdy bridge type pointer suspension, has internal components mounted on baseplate. It is supplied with universal mounts — flush or surface — and encased in a dust and moisture-resistant metal cabinet. Case features flush mounting. Weston Instruments Div., Daystrom, Inc.

24 — ANGLE VALVE serves double-purpose role

No. 74 Angle Valve doubles for liquid level gaging and instrument piping, combining in one unit features designed to prevent freezing and eliminate wear due to galling. With addition of a pipe plug with integral bleed fitting, basic level gage becomes an instrument



valve, 74G, eliminating multiple connections in instrument and general use. Manufacturer notes that this valve combines advantages of a single-piece forged valve body and bonnet flange to which is mounted a simplified outside screw and yoke bolted bonnet and reciprocating backseating stem. Bolted bonnet uses a forged yoke which supports stem away from valve body and a separate forged gland-follower which bears directly on packing and is independent of yoke. This construction places threaded portion of stem outside valve body, where it is not affected by temperature of liquid being handled. Valve has an ASA rating of 1440 lb, 100 F and a

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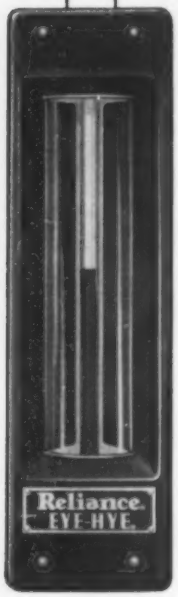
Why a remote reading gage

- Most boiler drums are high — direct gages are far from operating floor.
- Obstructions often make gages hard to see — necessitate special equipment or frequent climbing to inspect.
- Remote gage saves thousands of steps, hours of valuable time. Brings gage reading *down to eye level* at safe distance from boilers.



Why Reliance EYE-HYE

- EYE-HYE assures perfect measurement, dependability and clear reading.
- All-hydrostatic principle — no mechanical parts — no adjustments on location.
- Reads in liquid, like a conventional gage, but easier, faster because of illuminated green indicating fluid.
- Oldest practical remote gage — over 13,000 in use — on land and sea.
- Economical special attachment actuates supplementary alarms, audible or visible, if desired.

- Available for either wall or panel mounting, new wide-visibility EYE-HYEs are made for any pressure range — up to 3000 psi. Also long window model for unusual liquid level variation — for tanks, heaters, etc.

Write for catalog information on EYE-HYE for *your* boiler pressure.

The Reliance Gauge Column Co., 5902 Carnegie Ave., Cleveland 3, Ohio

Reliance BOILER SAFETY DEVICES

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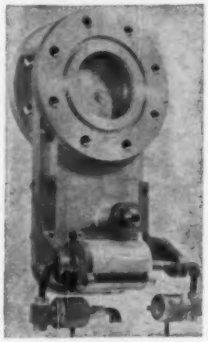
commercial rating 4000 lb. It weighs 8 lb, is available in various connections and materials, including Teflon. Jerguson Gage & Valve Co.

25 — CONTROL CENTER for central station use

This control center, designed for use in generating stations, provides for the group control of motors through 200 hp. All controls are centralized in one group of standardized enclosures 90⅜ in. high. Modular units have uniform width and depth while heights vary from 14 to 70 in. in multiples of 14 in. Units are accessible from front and wiring is accessible through hinged, full-length rear doors. Compartments are isolated by individually interlocked doors and breaker handles must be turned to "off" position before door can be opened. Baffling in each starter unit serves as a de-ionizing safety shield for localizing any fault. Knockouts in right-hand supporting member of each unit permit wires to be fed directly to rear wiring compartment. Westinghouse Electric Corp.

26 — VALVE OPERATOR is air operated, remote control

This air operated control for high vacuum gate valves is designed to effect 180 deg of rotation of a valve stem, but would be useful for a variety of similar control applications. Features include space-saving compactness and fast operation. The principle is simple rack-and pinion. Piston is fixed and cylinder carries the rack. Air moves the cylinder to turn pinion gear mounted on valve stem. Design permits operator to read position of gate at valve location, or remote indicators may be installed. Manual operation is possible in case of power failure where systems are based on electrically operated solenoid valves, or in case of air pressure failure. Device can also be wired to effect automatic, instant closing or opening in case of power failure. Vacuum Research Co.



27 — SPRAY-ON LUBRICANT increases open chain life

Packaged in a 16-oz push-button aerosol container, this lubricant can be applied to conveyor, elevating and transmission chains. It is formulated especially for use on open chains and combines features of a penetrant, lubricant and rust-preventive. According to manufacturer, it can lengthen open chain life up to 300 per cent, and was developed to work into close-tolerance, internal friction surfaces of open chains — between bush-

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When packing high-speed rotary air compressors, he will use Type #3—a metallic and asbestos packing that lubricates itself, maintains low friction, and runs cool in the absence of liquid.

Whatever your packing requirements, join the thousands of maintenance men that are "Seveneering" with R/M. They are using the Big 7 Packing Types to eliminate selection error and reduce inventory. They know that each packing is correctly engineered for the job it is to do. Frequently they find that three or four types will satisfy their needs without compromise in performance.

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BIG 7 PACKINGS

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PACKING DIVISION, PASSAIC, N. J.
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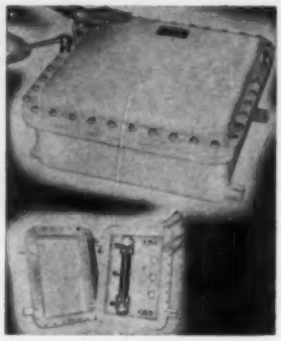
ings and pins and bushings and rollers — to reduce wear and dissipate heat. It is said to produce a smooth oily texture suitable for any climate. A trial can is free to qualified power engineers. The Whitmore Mfg. Co.

28 — CAST-ALUMINUM HOUSINGS are explosion-proof

Cast from aluminum alloy, these explosion-proof housings were tested at pressures to 275,000 lb force exerted against the cover, for UL listing in Class I, Group D and Class II, Groups E, F, and



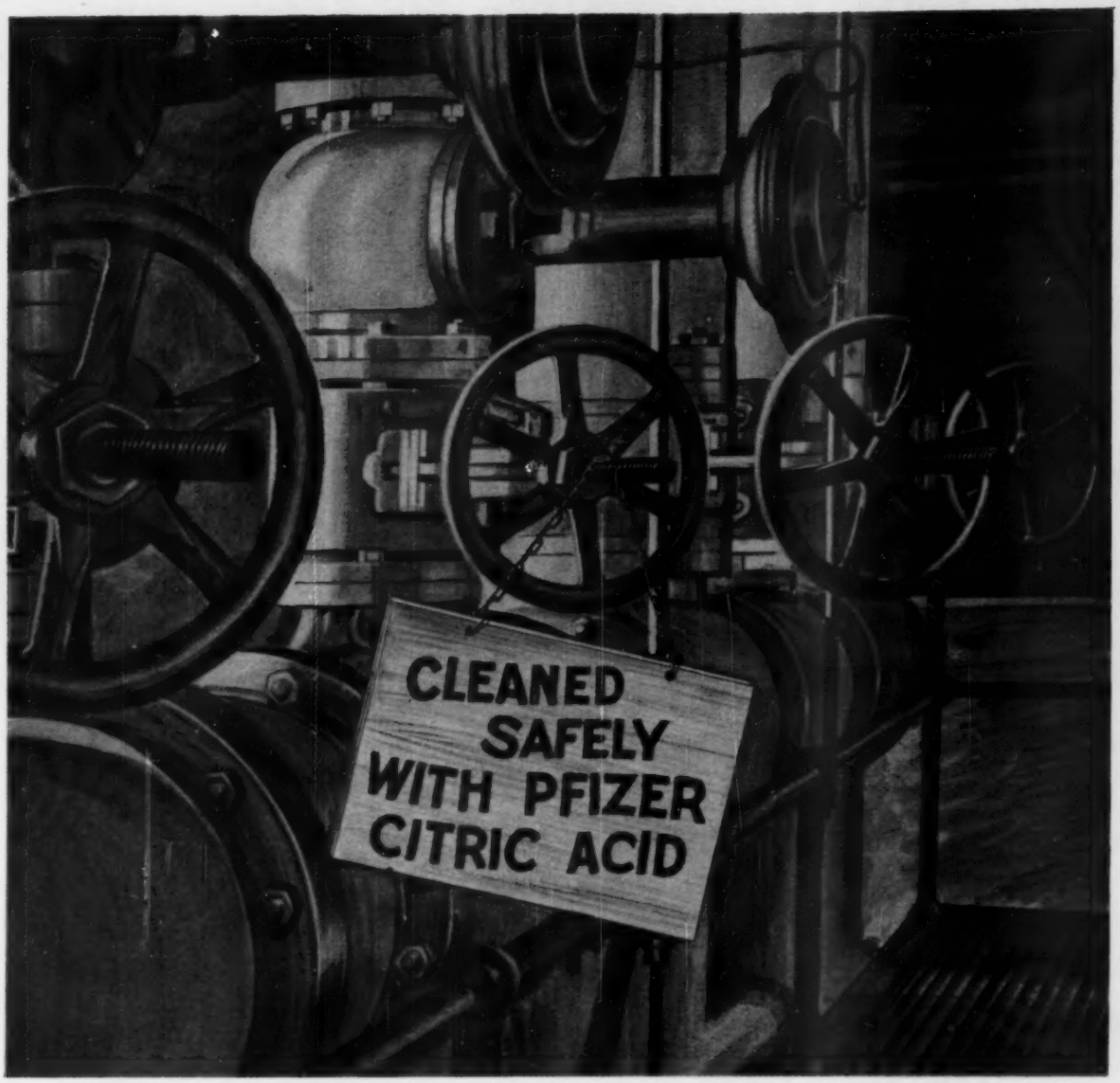
G hazardous locations, it is announced. In addition, company says, housings will not rust, are non-magnetic, non-sparking, and are light in weight. Flanged surfaces are ground flat to 0.0015 in., and do not utilize gaskets. Applications include housings for equipment starters, relays, splices and permanent terminal panels. Housings are furnished blank in 33 sizes up to 24 by 24 by 8 in. Bulletin 160 gives details. The Adalet Mfg. Co.

29 — UNIT SUBSTATIONS utilize four types of transformers

Shipped fully assembled, these integral distribution centers are compact, coordinated substations for supplying power to industrial, commercial and institutional buildings. Four transformer types — open and sealed dry-types, 300 kva and above, and oil and Pyranol filled, 112½ kva and above, are used. The open dry-type unit, for indoor use, features low sound, light weight and fire resistance. Pyranol filled centers and sealed dry-types may be used for indoor and outdoor applications in dirty or contaminated atmospheres. Oil-filled units can be installed anywhere outdoors, or indoors in a fireproof vault.

The centers incorporate an incoming cable termination compartment or high voltage switch, a transforming section, and a low voltage section containing breakers or feeders to meet requirements of light to medium power load applications. Standard low voltage terminations include a choice of one large air circuit breaker — electrically or mechanically operated — a molded-case circuit breaker or a motor starter panelboard (up to NEMA size 3). Sizes through 2500 kva are available provided breaker interrupting capacities are not exceeded and the number of breakers does not exceed the physical size of low voltage compartment. The center transforms primary 2400–15,000 v down to utilization voltage of 480Y/277, 480 Delta, 240 Delta, or 208Y/120 v. General Electric Co.

more Equipment News page 127



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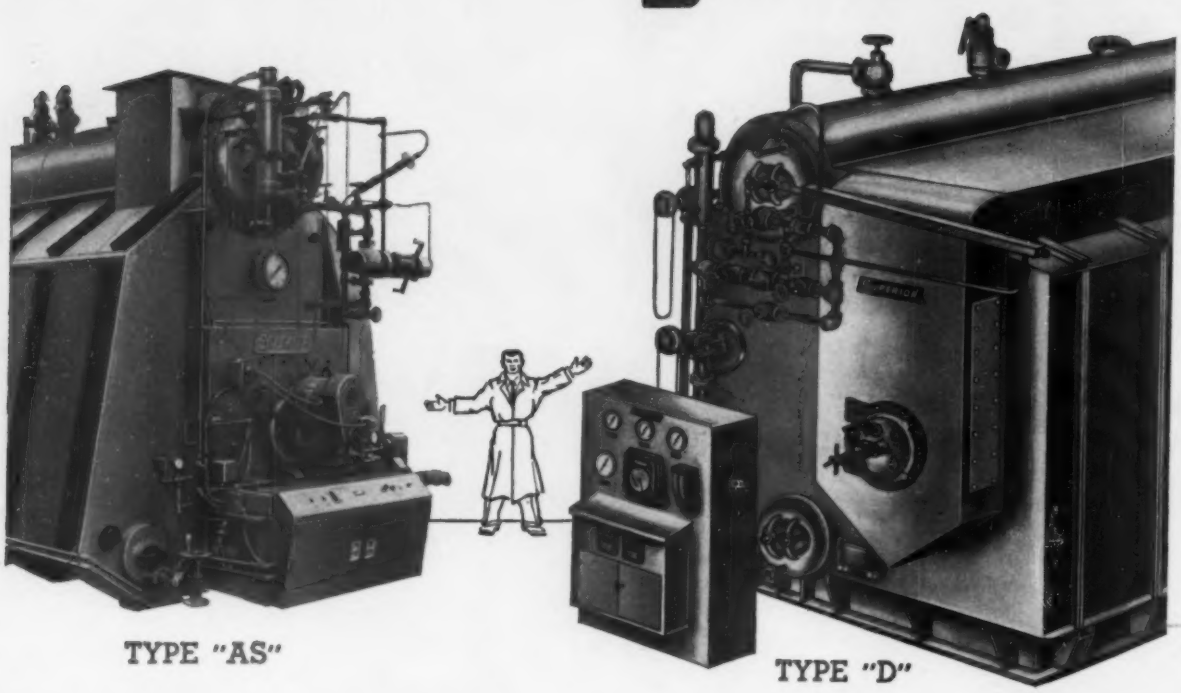

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The Type D Superior Packaged Boiler covers a broad capacity range from 11,000 to 61,000 lbs. of steam per hour. To the time-tested and well-known advantages of its basic design, Superior's Type D brings a number of exclusive features. Not the least of these is its rear-mounted draft fan which provides quiet operation, stable flame propogation by uniform burner register performance, air-cooled furnace roof and air-cooled firing wall. Maximum flexibility in the selection of firing and control equipment match the most exacting demands of industry.

The Type AS Superior Packaged Boiler brings to small steam plants the basic advantages of water tube boiler performance. Eliminating the problems resulting from compromising existing designs . . . shortened and baffled to provide lower capacities and required transfer rates . . . the Type AS is specifically designed for the 4,000 to 21,000 lbs./hr. range, incorporating not only features of larger units, but with exclusive features which will be adapted to units of greater capacity.

To provide true power plant performance over the wide range of capacities for which packaged boilers are today specified, Superior offers two basic designs. *No single* design can encompass this entire range without compromise. Both of these designs are true packages . . . completely factory assembled, factory-fire-tested and backed by unit responsibility.

Whatever your capacity requirements, you can specify a Superior Packaged Boiler without compromise. Careful comparison will prove that no other product offers so much. Our engineers are available to help you make that comparison. You'll profit by seeking their assistance.

For complete details of Type D, write for Catalog D-12.
For complete details of Type AS, write for Catalog 12S.

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PUMPS AND COMPRESSORS

201 Single Suction Pumps — Ball bearing single suction pumps are illustrated and described in 24-pp Bulletin 976-H. General data and specifications are included, as well as rating tables, outline dimensions, sectional drawings. Buffalo Pumps, Div. Buffalo Forge Co.

202 For Abusive Pumping Jobs — Catalog 5206 covers centrifugal pumps for wide industrial use and especially adapted to handling ashes, abrasive mixtures, slurries, hot and corrosive liquids. It describes several basic types: a horizontal shaft, single-stage side suction pump; a horizontal shaft, single-stage, rear-entrance automatic priming pump; vertical shaft pumps with standard, overhead and quill bearings for wet pit applications. Nagle Pumps.

203 Power Plant Pumps — Bulletin BJP-588 describes standard pumps for all power plant requirements — from 12,000 hp, double-case boiler feed pump, to condensate, circulating and booster pumping duty. Also describes special pumps for nuclear power plant installation. Byron Jackson Pumps, Inc.

204 Chemical Feed Systems — Bulletin 558-3 describes a line of controlled volume pumps and accessories for feeding water treatment chemicals. Design and construction features are detailed, and specifications given. Milton Roy Co.

205 Air Compressors — Stationary air compressors for continuous, heavy duty service in industry are illustrated and described in Bulletin A-62. Contains specifications, diagrams, cross section drawings, and installation photos. Joy Mfg. Co.

INSTRUMENTS, CONTROLS

206 Metering Control Systems — Bulletin 500 describes purpose, design and operation of company's metering and control systems. Includes discussion and pneumatic control, along with detailed literature references. Bailey Meter Co.

207 Basic Controls — Nine basic types of temperature and pressure controls are described in this 12-pp condensed catalog. Covers self-operating regulators, water mixing equipment, pneumatic control instruments, indicating and recording instruments and control valves. Equipment is designed for industrial process control, also for heating, ventilation, and air conditioning systems, and hot water service applications. Powers Regulator Co.

208 Instruments and Controls — Catalog 57-6 describes instruments and controls, including flow meters, liquid level or pressure gage, CO_2 meters, boiler me-

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209 **Ion-Exchange Controls** — Bulletin E-158 describes automatic control systems for ion-exchange equipment. Standards designed to assure proper performance of control units are detailed, and various elements in the control cabinets, as well as the power-operated units, are described. Specifications for electrical controls are also included. Illinois Water Treatment Co.

210 **Continuous Stream Analyzers** — Illustrated and described in 8-pp Bulletin CL-4000 is a line of continuous stream analyzers, including pH equipment, gas chromatographs, infrared analyzers, oxygen analyzers, electrolytic hygrometer, flow colorimeter, and thermal conductivity gas analyzer. Typical applications are listed. Beckman Instruments, Inc.

211 **Temperature Regulators** — Described in 16-pp Bulletin 8307-A are self-contained temperature regulators available in direct operated types for small flows, heating or cooling; pilot operated, for heating or cooling; and pilot operated Duomatic, temperature and pressure control for heating only. Detailed specifications, sizing and capacity data are included. Leslie Co.

212 **Guide to Gages** — Catalog 200-B, 112 pp, features Ashcroft, Duro-gauges, Maxisafe, pneumatic receiver, recording, quality, drawn case, chemical and special application gages. Also presented are gage testers, pneumatic transmitters, gages for nuclear energy. Engineering data and charts are provided. Instruments shown cover dial sizes from 2 through 24 in. Manning, Maxwell & Moore, Inc.

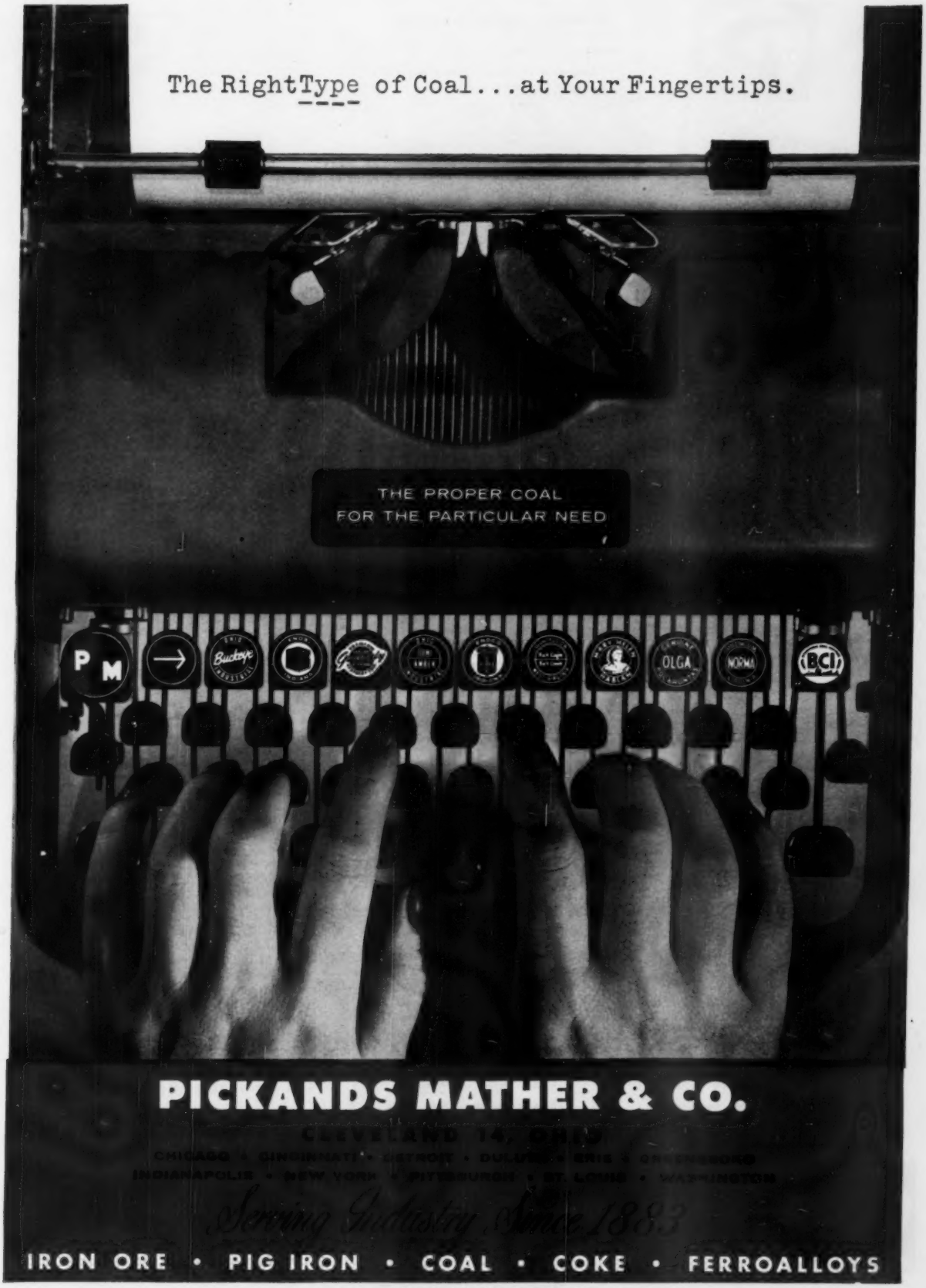
213 **Water Columns, Gages** — Featured in Bulletin 616B are boiler water columns and gage equipment. Illustrates and describes water columns for all pressures, as well as remote reading gages, liquid level alarms, water gage illumination equipment, and electrode-type liquid level alarms. Reliance Gauge Column Co.

214 **Thermocouple Adapter** — Bulletin 2A describes a spring-loaded bayonet-lock thermocouple adapter which converts any ¼ or 1/16 in. diam metal-shaped thermocouple to a spring-loaded, bayonet-lock type with adjustable immersion lengths. Specifications are given. Thermo Electric Co., Inc.

215 **Analog Computer Control** — Bulletin MSP-163 contains detailed information on a solid state, magnetic analog computer for industrial process control applications. Describes basic elements of the control and diagrams some interchangeable circuits possible with various components. Hagan Chemicals & Controls, Inc.

216 **For Wet Salt Storage** — A water control system designed specifically for wet salt storage is described in this 8-pp Booklet, B-669 P. Advantages of the automatic control are covered, and diagrams of various assemblies included. Morton Salt Co.

217 **Instrument Tubing** — Detailed information on various types of instruments, pneumatic transmitters, strip chart recorder, pressure, vacuum and differential recorders, temperature recorder, multipoint gages and others. Includes descriptive data. Republic Flow Meters Co.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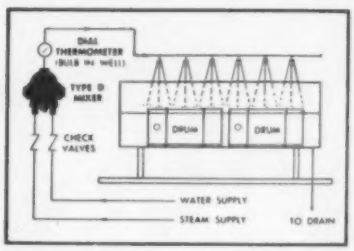

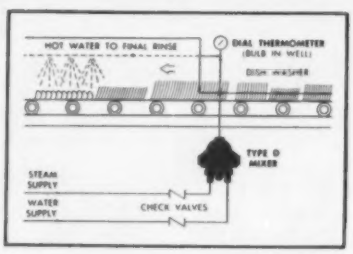

Schematics above show the function of Powers Type D Mixer in standard systems for maintaining uniform process hot water temperature where it is not practical to install or use a steam heated storage tank. These drawings are taken from the Powers *Engineer's Manual, Steam-Water Service* which is free to you for the asking. Each drawing is supplemented with detailed engineering information about the controls used. Everyone concerned with the installation and/or operation of steam-water service will find these diagrams a helpful guide in laying out a new system or updating an existing one. Other sections offer similar easy-to-follow diagrams and concise details on the following:

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- Instantaneous Heat Exchangers
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ment tubing and accessories is presented in this 16-pp bulletin. Among tubing described is extruded polyethylene tubing, extruded nylon tubing, tubes of copper, aluminum, and/or steel with polyethylene sheath, tubing with vinyl sheath, bundled instrument tubing. Dekoron Products Div., Samuel Moore & Co.

BOILERS, GENERATORS

218 Automatic Boiler — Application of the Coal-Pak automatic package boiler to low-pressure steam heating, hot water heating, and high-pressure process steam is covered in 36-pp Guide Specifications GS-3. Sample specifications include coal and ash handling, wiring, and boiler room layouts. Bituminous Coal Institute.

219 Boilers for Many Services — This general product data catalog contains detailed literature on the company's line of boilers for heating, power and process steam. It contains separate data sheets for each product, including high pressure and low pressure boilers, boiler-burner units and water heating equipment. In addition to photos and diagrams illustrating design and operation features, it provides tabular engineering data. Industrial Div., American-Standard.

220 Steam Generator — Bulletin F-14 contains 32 pp of detailed information on company's water tube type steam generator. Photos and diagrams illustrating design and construction features are included. E. Keeler Co.

221 Packaged Boiler — Features and advantages of company's completely packaged fire-tube boiler, Type CF, for capacities from 400 to 600 bhp are detailed in this product bulletin. Cutaway view showing component features is included, as well as data and dimensions. Superior Combustion Industries, Inc.

222 Packaged Steam Generator — Advantages of company's baffleless, pressurized two-drum water tube packaged units are detailed in 12-pp Catalog SB-59. Features of the completely integrated generating plant, which requires no field piping, wiring, brickwork or special foundation, are shown. Erie City Iron Works.

223 Packaged Generators — Booklet PG-58-2, on packaged steam generators, covers features, standard and optional equipment, capacities and dimensions. Foster Wheeler Corp.

224 Integral-Furnace Unit — Bulletin G-94 describes the Type PFI integral-furnace boiler, a pressurized-furnace oil- and gas-fired steam generator for power, process or heating loads requiring steam capacities to 400,000 lb-hr at pressures to 1150 psi and temperatures to 900 F. Includes information on membrane wall. The Babcock & Wilcox Co.

REFRACTORIES

225 Refractory Cement — Heavy duty brick bonding and patching mortar is described in this 8-pp illustrated color folder. Includes success stories concerning the product's application in high temperature work and in the protection of equipment against slag, fly ash and gases. Refractory and Insulation Corp.

226 Refractory Mortar — This is a 24-pp manual covering the use of Lumnite

calcium-aluminate cement as a mortar mix for gun-applied linings in power plant, refinery and metalworking equipment. Includes data on mortar preparation, placing procedures, curing; also information on use of Lumnite cement as a masonry mortar for laying brick. Universal Atlas Cement Div., United States Steel Corp.

INSULATION

228 Insulation Specifications — This 50-pp manual of specifications, IN-128A, is designed for the power, chemical and petroleum industries. It is divided into five sections — insulations for temperatures above 100 F; those for temperatures below 100 F; tank insulation; sphere and spheroid insulation; regenerator, catalytic reactor and oil heater lining and insulation. Tables include recommended thicknesses for both steam generating plants and process equipment based on average economic conditions for the industries and recommended thicknesses of insulation to prevent sweating. Johns-Manville.

229 Pipe Insulation — Featured in brochure J-432 is a lightweight, flexible, one-piece pipe insulation composed of incombustible, moisture-resistant mineral wool fibers, bonded with a phenolic resin and molded into 6-ft long sections. Characteristics of the material are described. Baldwin-Ehret-Hill, Inc.

230 Insulation Specifications — This set of six specifications covers applications of Foamglas insulation for industrial equipment and piping. Each booklet contains tables of suggested thicknesses of insulation to be applied, drawings of installation procedure, supports, and recommended finishes. Booklets are devoted to low-, medium-, high-, and dual-temperature equipment and piping, to underground piping, and spheres. Pittsburgh Corning Corp.

WATER CONDITIONING

231 pH and Chlorine Control — The 14th, 1959 edition of company's handbook, "Modern pH and Chlorine Control," 100-pp, incorporating theory and practice of colorimetric analysis, serves as a reference for quantitative determination of pH, chlorine, phosphate, nitrate, sulfate, hardness and other tests. Slide comparators and complete test kits are illustrated. In addition to standard pH determinations, methods are outlined for quantitative analyses of phosphate, calcium, magnesium, silica, nitrate, hardness. Available to qualified power engineers, please state your job title. W. A. Taylor Co.

You'll save time in ordering bulletins by using the Reader Service Cards on page 118. Of course we honor letterhead requests—but it takes us somewhat longer to handle them.

232 Cooling System Treatment — Bulletin C1 describes advantages of company's treatment for cooling tower systems with synergised polyphosphates. Details of the system are fully covered. Nalco Chemical Co.

233 Feedwater Heaters — Open-Coil, tray-type feedwater heaters and purifiers of both deaerating and nondeaerating

good for another 50 years
it's a Green fan!

We had a phone call the other morning...Nothing unusual about that—people do call us. This caller said he had an old Green fan, and wondered if we'd care to look it over. Figured we might have a buyer for it.

Well, it turned out that this was one of our earliest fans, the sixth fan we made, in fact. Every bit of it, fan, shaft and housing, was designed and made in our plant in 1903. Now, 1903 is so long ago even the name of our town has since been changed from Matteawan to Beacon.

For 55 years this Green fan had been used in a lumber mill for exhausting shavings from a planer. The building in which the fan was housed was torn down early in 1958. Everything but this Green fan had been carted away.

We went over that fan inch by inch, and bought it for ourselves to keep as an example of Green's workmanship.

Know something? It could be started up today, with no repairs, and we feel it would run satisfactorily for another 50 years. Just goes to show ....when Green builds a fan, well—it's built!

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type are presented in 12-pp Bulletin 117A. Construction and operational features of the heaters are explained and illustrated, and more than a dozen available models are pictured along with application suggestions. Stickle Steam Specialties Co.

234 Boiler Water Treatment — Chemical reduction of oxygen in boiler feedwater with hydrazine is the subject of 10-pp Bulletin BW. Economy and operation, handling of the Deoxy-Sol, methods of analysis and other details are covered. A bibliography lists supplementary reading. Fairmont Chemical Co., Inc.

235 Corrosion Control Tips — Control of water problems in air conditioning system — scale formation and slime and algae growths — is discussed in Bulletin 596. Offers suggestions for the control of these problems through adequate, planned chemical treatment. Application information as well as control testing data are included. Betz Laboratories, Inc.

236 Condensate Corrosion Control — Advantages of company's film-type amine for controlling corrosion in steam condensate systems are detailed in Bulletin 410. Typical applications are described. Hagan Chemicals & Controls, Inc.

FUEL BURNING EQUIPMENT

237 Water-Cooled Stoker — Design and operating advantages of the Vibragrate Stoker are outlined in this illustrated bulletin. A large cutaway view details component parts of the stoker and explains operating features. Other drawings show installations. American Engineering Co.

238 For Burning Refuse Fuel — This 8-pp bulletin describes refuse fuel burning equipment, including a pneumatic refuse fuel distributor which spreads refuse fuel such as bark, wood chips, and bagasse uniformly over the grate surface. Discusses various components. Riley Stoker Corp.

239 Oil, Gas Burners — Bulletin G59 describes a combination gun-type gas and steam-atomizing oil burner unit. Features and advantages are detailed. The Engineer Co.

240 Better Fuel Performance — This bulletin describes two of company's products designed for better fuel performance and economy. The first is a fuel oil sludge dispersant which prevents sludge and moisture separation in heavy fuel oil. The other is a soot remover. Western Chemical Co.

241 Pump and Heater Sets — Bulletin 15 describes packaged fuel oil pump and heater sets designed for accurate control of temperature and pressure of heavy oils to insure proper atomization and combustion. Features are described and data presented. Walter H. Eagan Co., Inc.

TUBING AND ACCESSORIES

242 Tubes and Plates — Publication B-2, 46 pp, covers the subject of tubes and plates for condensers and heat exchangers. Field of application and particular problems encountered in each are described. Information on condenser tube alloys, plates for tube sheets and baffles, manufacturing methods, installation, operational factors affecting tube life, corrosion factors in condenser tube service is presented. The American Brass Co.

243 Tube Cleaner — Featured in Sheet A-24 as a condenser and heat exchanger tube cleaner weighing only 10 lb. Operation advantages are detailed and specifications listed. Airetool Mfg. Co.

244 Tube Expanding — The technique of tube rolling in thick tube sheets is discussed in Bulletin Y-52. Various methods of rolling are detailed, and advantages of continuous rolling described. Elliott Co., Div. Carrier, Corp.

245 Tube Cleaners, Expanders — Comprehensive information on maintenance tools for all types of tubular equipment is presented in 120-pp Catalog 77–88. Includes detailed suggestions on selection of tube cleaning equipment for various applications, data on condenser tube cleaners, vibrator cleaners for fire tube boilers, other boiler tube cleaners, water driven cleaners, vapor generator tube cleaners, wire brushing equipment, tube cleaner hose, lubricator, valves and manifolds, electrically driven cleaner, chipping and surfacing machine. Book is available to qualified power engineers. Thomas C. Wilson, Inc.

ELECTRICAL EQUIPMENT

247 Handbook on Fuses — This 12-pp booklet contains practical information on how to get safe, dependable, trouble-free electrical protection. Shows what to do when fuses blow, how to determine cause of blows, what kind of fuse to use for various circuits. Contains short history of fuses and notes on construction of fuses. Bussmann Mfg. Co.

248 Dielectric Test Set — Bulletin 22-5 describes an instrument in bench and portable models for making step-voltage-current (or resistance) tests, voltage withstand and breakdown tests on the insulation of electrical equipment with ratings of 300, 600, 2500 v and higher. Specifications and prices are included, also outline of design and operating features of the instrument. James G. Biddle Co.

249 Cable Troughs — This 28-pp catalog offers a simple solution to any design problem of change of direction or elevation with a complete set of standard fittings, horizontal elbows, inside and outside vertical elbows, ties, crosses, covers and special devices. The Globe Co.

VALVES, TRAPS, PIPING AND FITTINGS

250 Safety, Relief Valves — Performance data on company's safety and relief valves is presented in 24-pp Catalog 1000-V. Steam, air and water capacity tables are included, as well as cutaway views showing component details, and dimension tables. J. E. Lonergan Co.

251 Boiler Blow Off Valves — Bulletin E-125, 24 pp, describes and illustrates the design and construction of company's quick-operating valves, angle valves, Y valves and duplex units specifically designed for boiler blow-off service. Includes dimensions. Everlasting Valve Co.

252 Butterfly Valves — Comprehensive information on rubber seat butterfly valve designed to mount between pipe flanges is presented in Bulletin 10. Includes technical data on plans stem valve, handlever operator valve, manual operator valve, buried operator valve, floorstand

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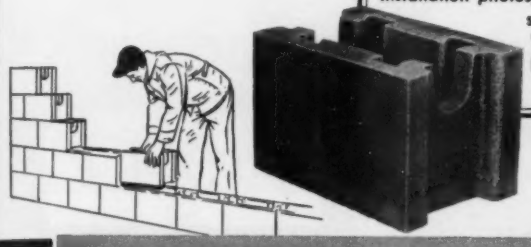

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operator valve, electric motor operator valve, diaphragm operator valve, water flow characteristics of butterfly valves, gas flow characteristics. Henry Pratt Co.

253 Blow-Off Valves — Unit-tandem blow-off valves for medium pressure boiler installations are featured in Bulletin B-435. Operation and design features are detailed, materials of construction described, and dimensional and specification data given. Yarnall-Waring Co.

254 Bronze Gate Valves — Presented in this product bulletin, Form 198, is a line of bronze union bonnet gate valves for 125 to 150 WSP. Features are shown on cutaway view, and dimension given in tables. The Wm. Powell Co.

255 Silent Check Valves—Described in Bulletin WH-654 are silent check valves featuring low frictional rsistance. Tables list dimensional data and reasonable velocities for flow of water through pipe, fittings, and valves. The Williams Gauge Co., Inc.

256 Reducing Valves — Direct-operated water pressure reducing valves are featured in illustrated Bulletin 1009. A cutaway view showing component features is included, as well as water capacity table, dimensional tables and diagrams. Spence Engineering Co., Inc.

257 Insulated Piping — Described in 20-pp Catalog 59-1 are prefabricated insulated piping systems for underground and overhead use. Cutaway views showing design and construction features are included as well as dimensional diagrams and data, and photos of typical applications. Ric-wiL, Inc.

258 Valve Operator — Catalog 14-C describes a ring gear and pinion assembly permitting a man with a portable air wrench or electric wrench to operate large cast steel globe valves without assistance. Included is data on stall torque and free speed requirements of wrenches suitable for use with valves. Edward Valves, Inc.

TURBINES, ENGINES

259 Steam Turbines — The advantages of company's solid wheel turbines, axial flow turbines, single stage and multistage, are outlined in illustrated Bulletin S-140. Describes various models in their line and includes application photos. The Terry Steam Turbine Co.

260 Gas Turbine Engines — Featured in this 24-pp bulletin are engine data, performance curves and applications for company's gas turbine engines. Explains operation of gas turbines and includes photos showing applications, as well as engineering diagrams. Solar Aircraft Co.

261 Steam Turbines — Single stage turbines for mechanical drives are featured in 6-pp Bulletin T-126. Schematic drawings showing component features and details of operation and design are included. Murray Iron Works Co.

VENTILATING, REFRIGERATION AND AIR CONDITIONING

262 Refrigeration Condensers—Engineering data on a complete range of sizes and types of refrigeration condensers are featured in 38-pp Bulletin RG-2. Rat-

ings in tons refrigeration are tabulated for large and small ammonia condensers, vertical ammonia condensers, ammonia condenser-towers, freon condensers and freon condenser-towers. Selection data, dimensions given. Henry Vogt Machine Co.

263 Refrigerated Purging — Helpful data on purging refrigeration systems is presented in 12-pp Bulletin 700. Covers basic principles of automatic purging, selection, installation and operation of purges, and specifications. Armstrong Machine Works.

264 Air Conditioners—Bulletin 133 describes a line of air conditioners designed to use Freon, methyl, chloride, ammonia or cold water refrigerants. Engineering data and photos of typical installations are included. Niagara Blower Co.

Postage-free cards for ordering catalogs are on page 118. You may also use the cards to order literature mentioned in the ads.

265 Air Engineering — Bulletin E-57 is a 24-pp air engineering data file covering engineering and test facilities for propeller fans, specifications, construction, maintenance, and installation. Tables for estimating air-handling requirements, entrance and elbow losses are provided. Aerovent Fan Co., Inc.

OTHER EQUIPMENT

266 Story of Coal — This pocket-size booklet presents a complete picture of company's operations, traces the history of the coal industry and describes the many services and applications of coal. A colorful mural reproduced in the booklet pictures the part coal has played in civilization. Peabody Coal Co.

267 Cranes, Hydro Equipment — Twelve-pp Brochure HY-51 describes cranes and equipment for hydroelectric, water supply and other applications. Various components and assemblies that help harness hydroelectric power are pictured, including cranes and hoists, gates and valves, and special hydroelectric equipment. Yuba Consolidated Industries, Inc.

268 Cooling Towers — Performance details on company's cross-flow cooling towers are presented in this 20-pp illustrated Booklet CF-59. Discusses and illustrates through diagrams the cross-flow principle of water cooling, and includes descriptions of equipment, engineering and design features. The Marley Co.

269 Soot Blower — Bulletin 1091-A describes features and advantages of company's automatic soot blower for efficient boiler cleaning. Operation details are diagrammed and data given. Diamond Power Specialty Corp.

270 Air Preheater — Featured in this 14-pp booklet is a line of package air preheaters for small boilers and process applications. Fuel savings data is presented, as well as diagrams of typical arrangements, and other details of design and operation. The Air Preheater Corp.

271 For Chemical Cleaning—Technical Bulletin 102, 'about 16 pp, presents application and other information

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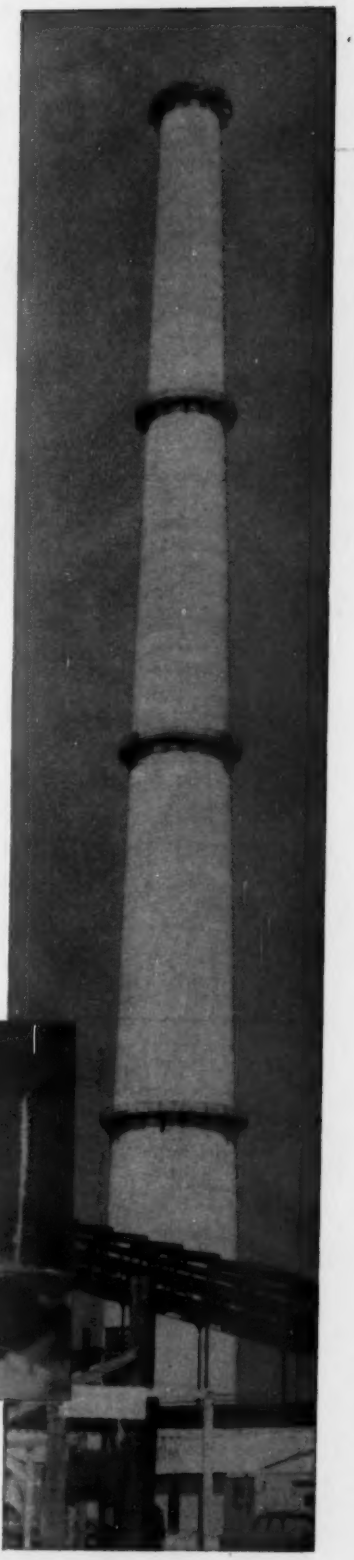
the acid-proof refractory lining, lengthens chimney life

Chimney life is increasing thanks to linings of FOAMSIL, the new insulating refractory by Pittsburgh Corning. This 99% pure foamed silica is completely impervious to acids, is not affected by hot, corrosive industrial gases.

FOAMSIL can take continuous operation at temperatures up to +2200°F . . . and stands up under temperature cycles ranging from −450°F to +1600°F.

Installation is a simple, low cost operation with FOAMSIL. Light in weight, it is easy to handle, yet strong and rigid—can be cut quickly and accurately with ordinary tools. It is available in blocks 17″ x 22″ in a variety of thicknesses, starting at 2 inches.

Put an end to costly relining of chimneys with materials of sometimes questionable serviceability. Write today for a sample, descriptive literature, and examples of successful FOAMSIL applications. Pittsburgh Corning Corporation, Dept. PES-40, One Gateway Center, Pittsburgh 22, Pa.



Pictured is a FOAMSIL lined chimney at Consolidated Edison Co.'s Arthur Kill Station. The inside was first coated with an acid-proof bituminous compound, then 2-inch thick FOAMSIL blocks were applied against it. A half-inch air space was allowed, and the interior completed with a lining of acid-resistant brick. The mammoth 500-ft. chimney serves a 335,000 KW capacity steam generator boiler.

PITTSBURGH pc CORNING

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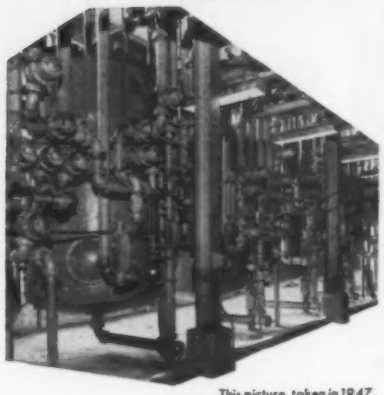

This picture, taken in 1947, shows a fully-automatic IonXchanger designed and built by IWT.

Leading the Way In De-I Developments

At the time the IonXchanger shown above was installed, Illinois Water Treatment Company already had a decade of design and manufacturing experience behind it. Many other firms, now selling in the field, then had yet to cut their teeth on their first small jobs.

Ash from Corn Syrup

This particular job was especially important because it pioneered successfully in one of the many process fields — other than the purification of water — where de-ionization was proving practical. The equipment is still operating at full effectiveness today in the big sugar refinery where it serves most economically to remove ash from corn syrup.

It is significant that IWT had this early experience in the design of automatic equipment, and so was ready for the widespread trend toward "automation" in many industries in recent years.

THIS EXPERIENCE CAN MEAN A LOT TO YOU

If you are considering the use of ion-exchange for the purification or concentration of chemical products, or if you need purified water for high-pressure boiler make-up or process use, be sure to take advantage of IWT pioneering experience and specialized knowledge. *Call your IWT representative.*

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on company's products for chemical cleaning. These include formulas for power plant cleaning, stainless-steel cleaning, aluminum and aluminum alloy cleaning, alkaline derusting and paint stripping, general cleaning, others. Also provided is chart of corrosion rates. Chas. Pfizer & Co., Inc.

272 For Desuperheating — Bulletin 1056 describes a carburetor-type desuperheater capable of being controlled to supply steam at a temperature within ± 5 F of plant requirements. Explains method of control and gives range of control attainable. Also describes structural details, system arrangements of components, and mechanical specifications. Copes-Vulcan Div., Blaw-Knox Co.

273 Aluminum Jacketing — Illustrated and described in this Bulletin J-1 of a line of aluminum jacketing for insulated lines and elbows. Typical applications in power plants, refineries and chemical plants described, and suggested specifications included. Childers Mfg. Co.

Catalogs reviewed here are offered primarily for qualified power engineers. Manufacturers may withhold literature from persons who do not state their job title and company. Some manufacturers also prefer not to send literature to those in foreign countries in which they have no sales representatives.

274 Coal Crusher — Company's WC and WS series rolling ring coal crushers are described in Bulletin 154. Emphasizes special construction elements that mean greater coal reduction at lower operating costs. Cross section illustration shows both feeding and crushing action incorporated and tables give capacities, speeds, and dimensions. American Pulverizer Co.

275 Mechanical Packings—Catalog P-210C contains 40 pp of detailed information on company's line of mechanical packings and gasket materials. It contains illustrations, descriptions, complete service recommendations and specification charts. Raybestos-Manhattan, Inc.

276 Rust Prevention — This illustrated bulletin describes company's rust eradicator for removing rust, scale and congestion from water systems, as well as the service offered by the company for assuring protection from the damaging effects of water. Photos of typical applications are included. The North American Mogul Products Co.

277 Sheet, Plate Fabrication — A variety of parts and assemblies — from massive boiler breechings to smallest stamping — are illustrated in 40-pp Bulletin F4. Facilities and equipment for production are illustrated, including shearing, contour cutting, punch press, large presses, brakes, welding, large and small structurals, assembly. The Kirk & Blum Mfg. Co.

278 For Process Industries — Featured in 12-pp Bulletin G-3C is a line of equipment for the process industries, including pneumatic conveyors, compressors and vacuum pumps, coolers and preheaters, blowers, gas and vacuum pumps, fans and exhausters, and accessory equipment. Ratings tables and other data given. Fuller Co.

THE LONERGAN LINE

HOW TO MAKE A GOOD IDEA BETTER

by Norman J. Smith

In this hurry-up age of missiles and electronics, it is often possible to overlook the fact that because a device or an idea is new, it is not necessarily the best.

For example, while there are many temperature and pressure sensing devices, none

has such universal application as the Bourdon tube, which was first conceived in 1849 by a French engineer, Eugene Bourdon.

Today, a modern "C" type Bourdon tube gauge, such as the Lonergan Maximon makes full use of Bourdon's original idea. At the same time, it utilizes the finest materials such as K Monel stainless steel, beryllium, copper and many, many others in order to improve Bourdon's basic invention. Other improvements are: twisted spiral tubes to measure the output of pressure transducers; long helical tubes with heavy walls to measure pressures up to 100,000 psi; and small tightly coiled tubes for movementless gauges.

While the power plant man with a gauge problem isn't concerned with all of these forms, it is interesting to note that in his application for a patent more than a hundred years ago, Bourdon anticipated all of these present day variations. He claimed application on all forms of curved or twisted tubes whose transverse sections differed from circular forms for temperature and pressure measuring, indicating and controlling of fluids.

The Lonergan gauge today incorporates all of the known advances in the Bourdon tube in any one of three lines. For applications requiring the finest gauge available anywhere, the Lonergan Maximon is the choice.

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Chief Engineer, Instrument Division

Lonergan

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continued from page 114

30 — DISCHARGE VALVE is rubber diaphragm peristaltic type

This valve is designed to handle coarse abrasives such as catalysts, pellets and other shaped materials unable to pass through conventional rotary valves. Its elliptical body and "sandwiching" of its sheet rubber diaphragms assure closure,

says manufacturer; movement is confined to the valve's gum rubber diaphragms which alternately open and close by air pressure or vacuum, and this action permits discharge of materials in measured quantities with air tight seal. There are no internal wearing metallic parts and the rubber diaphragms are easily replaced, it is noted, and should either diaphragm rupture, the other one is capable of complete closure. Air Appliance Div., U. S. Hoffman Machinery Corp.

31 — STEAM TRAP features a built-in union in inlet

Newest in this manufacturer's Quik-Flex line of industrial thermostatic steam traps is one with a union designed into the inlet of the trap itself. This union eliminates time involved in fitting pipe to a union, as well as the cost of a separate union and materials. Maintenance is simplified, since the trap can be disconnected by loosening a single fitting. The built-in union is available in traps in ½- and ¾-in. sizes.

Quik-Flex traps are reported to have outstanding condensate and air removal characteristics due to a phosphorous bronze and Monel bellows with con-

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Do It Better With *Thermo Electric* Thermocouple Extension Cables and Wires

You can obtain Thermo Electric thermocouple extension wire and cable in the widest variety of size, insulation, type and calibration, for your application—with prompt delivery of all standard materials.

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Individual or duplex thermocouple and extension wires are available in all standard calibrations—many in gages from 14 to 40—insulated with Polyvinyl Chloride, cotton lacquer, Nylon, Teflon, Fiberglass, Asbestos or combinations of these materials. Metallic overbraids of stainless steel and other high-temperature materials provide extra mechanical protection and shielding.

"Ceramo", Thermo Electric's metal-sheathed ceramic insulated thermocouple wire is used for extra-high temperature and nuclear applications.

Thermo-Electric also supplies thermocouple wires to meet Mil-Spec requirements.

For information on selecting the right wire for your application,

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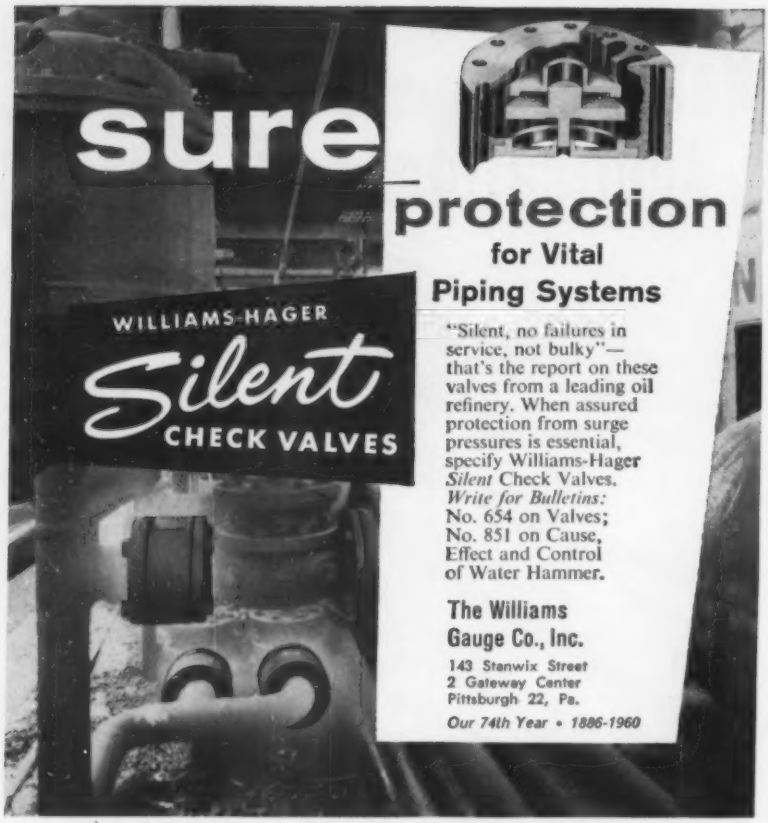
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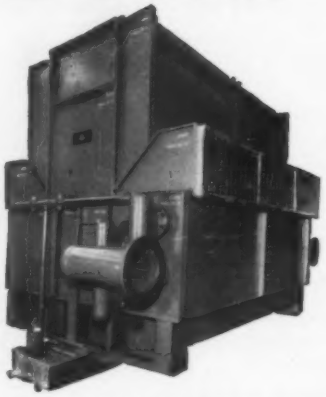
ECONOMICAL COOLING OF GASES AND COMPRESSED AIR



Cooling gases or cooling and removing moisture from compressed air, the Niagara *Aero* After Cooler offers the most economical and trustworthy method. Cooling by evaporation in a closed system, it brings the gas or compressed air to a point below the ambient temperature, effectively preventing further condensation of moisture in the air lines. It is a self-contained system, independent of any large cooling water supply, solving the problems of water supply and disposal.

Cooling-water savings and power-cost savings in operation return your equipment costs in less than two years. New sectional design reduces the first cost, saves you much money in freight, installation labor and upkeep. Niagara *Aero* After Cooler systems have proven most successful in large plant power and process installations and in air and gas liquefaction applications.

Write for Descriptive Bulletin 130.

NIAGARA BLOWER COMPANY

Dept. E-4, 405 Lexington Ave., New York 17, N. Y.

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stant spring load that opens when contacted by cold air or condensate. A downward flow design with no retaining cores or passages serves to keep condensate from cooling and freezing in the trap. It is suggested for use with tracer lines, meter boxes, drips — for ordinary drainage, and wherever temperatures drop below freezing. The traps are designed to discharge up to 31000 lb of condensate per hour, for pressures to 250 psi. Bodies are heavy duty bronze or semi-steel, valve and seat are Anderloy. Details are in Specification Sheet 2384. The V. D. Anderson Co.

Reader Service Cards on pages 117–118 make it easy to get further information on any of these products. Just circle the item numbers of the products you want to know more about.

32 — VERTICAL COMPRESSOR for ratings to 150 hp

The WG-9H is a vertical, single-stage compressor with piston displacements from 633 to 1630 cfm, maximum pressures to 125 psi and horsepower ratings to 150. This addition to company's line of heavy duty air, gas boosting and oil-free compressors gives three basic single-stage compressor models, and increases the number of sizes to 20 which include 5-, 7-, and 9-in. piston strokes. Bulletin GG-5H gives details. Joy Mfg. Co.

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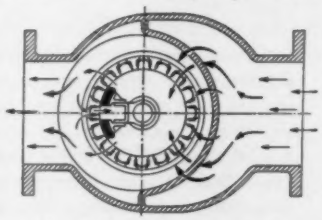

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CONSTRUCTION NEWS

Birmingham, Ala. — Alabama Power Co, Alabama Power Bldg, has announced that it has filed an application for a license to build a hydroelectric project on the Black Warrior River, in Tuscaloosa County, Ala, with the Federal Power Commission. Company has plans to construct a large hydroelectric dam and power plant and install generating facilities in the navigation dams, which will involve the expenditure of more than $10,000,000. Total installed capacity would be 40,000 kw.

San Diego, Calif. — San Diego Gas & Electric Co, 861 Sixth Ave, this city has announced plans for major expansion and improvements in its transmission and generating facilities and has authorized a $36,791,000 capital spending budget for the year, which is $3,200,000 higher than 1959. Major outlays will include $5,000,000 for increased generating equipment and powerhouse additions; $13,900,000 for expansion of electric transmission and distribution facilities, including substations; and $14,000,000 for gas transmission and distribution facilities. Utility now serves 316,000 electric and 255,000 gas customers in this area.

St. Petersburg, Fla. — Florida Power Corp, 101 S. Fifth St, this city, has authorized plans for the installation of the second steam-electric generating unit at its Bartow Power Plant on Weedon Island. Work on the new installation is already under way and is scheduled for completion early in 1962. Cost is reported to be about $10,000,000. Black & Veatch, Kansas City, Mo, is consulting engineer.

Chicago, Ill. — Commonwealth Edison Co, 72 W. Adams St, this city, has announced a major expansion program of its generating and transmission facilities over the next four-year period and has authorized the expenditure of $700,000,000 for construction of generating and distribution facilities to help meet the ever-increasing demand for power and electricity in the Chicago area and the northern part of Illinois, which the company serves. Some $160,000,000 is earmarked for expenditure this year, a like amount for 1961, $175,000,000 in 1962, and approximately $200,000,000 in 1963.

Winnetka, Ill. — Municipal Light & Power Dept, City Hall, plans expansion in the municipal electric plant. Contract award in the amount of $1,300,000 was awarded to Ragnar Benson Co, Inc, 4744 W. Rice St, Chicago, for the work which will get under way at once. Sargent & Lundy, also of Chicago, is the consulting engineer.

Tracy, Iowa — Iowa Power & Light Co, 823 Walnut St, Des Moines, Iowa, has plans under consideration for the construction of new power plant on a large tract of land recently acquired at this location. Company plans to start construction of new facility sometime this year. It will have an initial capacity of 150,000 kw and will cost about $20,000,000 when completed in 1963.

Cambridge, Mass. — New England Gas & Electric Assn, 727 Massachusetts Ave, has announced plans to construct a new five-story office building on new site recently acquired. Construction of the new facility, which will cost an estimated $1,000,000, will begin soon and will be completed sometime in mid-1961. New building, which will have office space of 45,000 sq ft, will serve as the new company headquarters, replacing the present building.

Chase, Md. — Baltimore Gas & Electric Co, Lexington Bldg, Baltimore, Md, has announced contract award of $6,000,000 to Babcock & Wilcox Co, 161 E. 42nd St, New York, N. Y., for the manufacture and installation of a cyclone-furnace-fired radiant boiler along with auxiliary equipment for its second turbine-generator unit now being installed at Charles P. Crane Power Station, near here. Work has already begun on the new unit, and completion is scheduled for late 1961 or early 1962.

Bridgman, Mich. — Indiana & Michigan Electric Co, 122 E. Wayne Ave, Fort Wayne, Ind, has plans under consideration to construct new power plant on Lake Michigan and Route 2, Lake Township, in Berrien County. Plant will have an initial capacity of 450,000 kw and will cost between $50,000,000 and $75,000,000 when completed. Construction will begin as soon as preliminary engineering work is completed.

St. Louis, Mo. — Union Electric Co of Missouri, 315 N. 12 Blvd, this city, has announced contract award totaling about $20,000,000 to Fruin-Colnon Contracting Co, St. Louis, and Utah Construction and Mining Co, San Francisco, Calif, for the proposed "pumped storage" project to be located near Lesterville, Mo (see March, 1960, POWER ENGINEERING, page 75). Company had recently announced that it would go ahead with the project, which is now scheduled for completion in 1963. The two firms won the contract as joint venturers. Contract is only part of the total cost of the project, which is expected to be about $50,000,000 when completed. Remaining $30,000,000 will be spent on generating equipment, design, transmission system, lands, and rights-of-way.

Atlantic City, N. J. — Atlantic City Electric Co, Kentucky and Pacific aves, this city, has plans under consideration for the construction of a new steam electric generating installation on the Great Egg Harbor River near Ocean City, N. J., during the third quarter of this year. Proposed unit should be placed in line by late 1962 or early 1963 and will cost an estimated $27,000,000 when completed. Company has also stated that a second generating unit would probably be started as soon as the first was completed.

Newark, N. J. — Public Service Electric & Gas Co, 80 Park Place, has announced plans to spend approximately $150,000,000 for new construction in 1960, the fifth consecutive year that the company's construction expenditures have exceeded the $100,000,000 mark. This will bring to more than $1 billion the amount expended for additions and improvements in company's generating and transmission facilities since 1951. Company will also spend another $40,000,000 for the construction and reinforcement of major high-tension transmission facilities. Installation at the Mercer Station in Hamilton Township of a 320,000-kw steam electric generating unit will be completed late this year with another to follow in 1961.

Syracuse, N. Y. — Niagara-Mohawk Power Corp, 300 Erie Blvd, has announced plans for a major construction project that will link its facilities with a new 345,000-volt system stretching across the state from the Niagara River Power project. Two new substations are planned, one on a site in nearby Clay, N. Y., and the other just north of Utica, N. Y. Plans also include the installation of about 160 miles of high-voltage transmission lines. Total cost of the expansion project is reported to be in excess of $18,000,000. Completion is planned for late 1961.

Oklahoma City, Okla. — Oklahoma Gas & Electric Co, 321 N. Harvey St, has authorized plans for major expansion and improvements of its facilities and has announced a construction budget in excess of $13,000,000 for construction projects this year. Major items planned for 1960 construction are electric distribution systems costing $4,510,000; meters and line transformers costing about $2,188,000; new transmission lines, $1,541,000; various buildings and structures, $1,266,000; and substation power equipment, $1,091,000. The 1960 budget is considerably below that of 1959 because no new power plants are planned this year.

Portland, Ore. — Pacific Power & Light Co, Public Service Bldg, this city, has announced that it has filed an application with the Federal Power Commission for a license to build a proposed Eden Ridge Power Project on the South Fork Coquille River in Coos County, Ore. Project, estimated to cost more than $23,600,000, would consist of the Eden Ridge Dam, 210 ft high and 740 ft long, and a powerhouse with a capacity of 77,000 kw. Company provides electric service in Oregon, Washington, Idaho, Montana, and Wyoming.

Carbo, Va. — Appalachian Power Co, subsidiary of American Electric Power Co, 40 Franklin Road, Roanoke, Va, has authorized plans for the construction of a new steam electric generating unit at its Clinch River Power Plant, located here. New installation, the third such installation at the plant to-date, will have an initial capacity of 225,000 kw. Work on the foundations and super structure will begin at once. New unit will represent an investment of about $28,000,000, and when completed late in 1961, will increase the total capacity of the Clinch River Plant to 670,000 kw.

Covington, Va. — West Virginia Pulp & Paper Co, 230 Park Ave, New York, N. Y., has begun work on the installation of a large power boiler with auxiliary equipment and generator plant at local paper mill here. Company has awarded contract to the Combustion Engineering Co, Inc, 200 Madison Ave, New York, N. Y., for the construction and installation of the 500,000-lb-per-hr steam generating unit to be used in connection with company's wood pulp and paper-making operations. Work, to cost about $3,000,000, will proceed under the direction of Gibbs & Hill, Inc, New York, N. Y.

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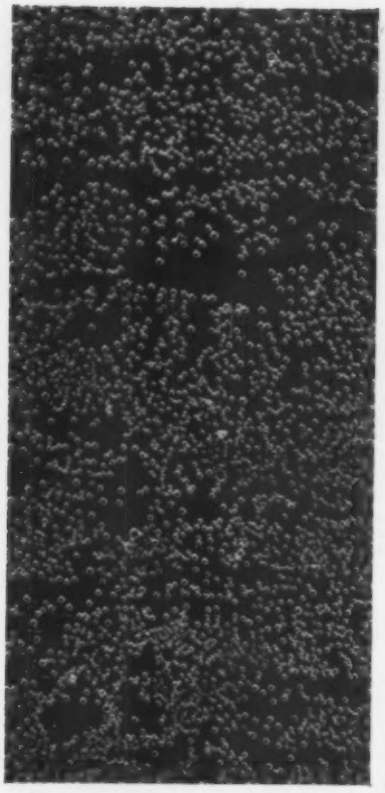

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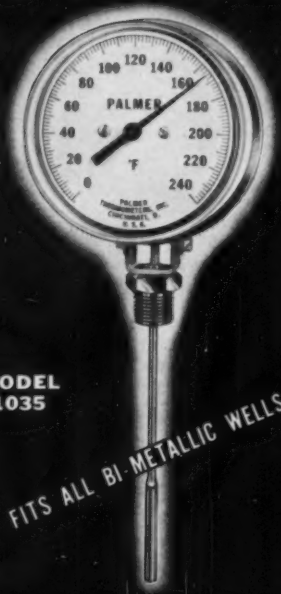

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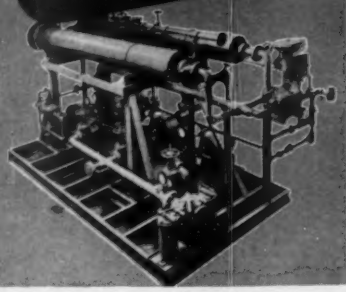

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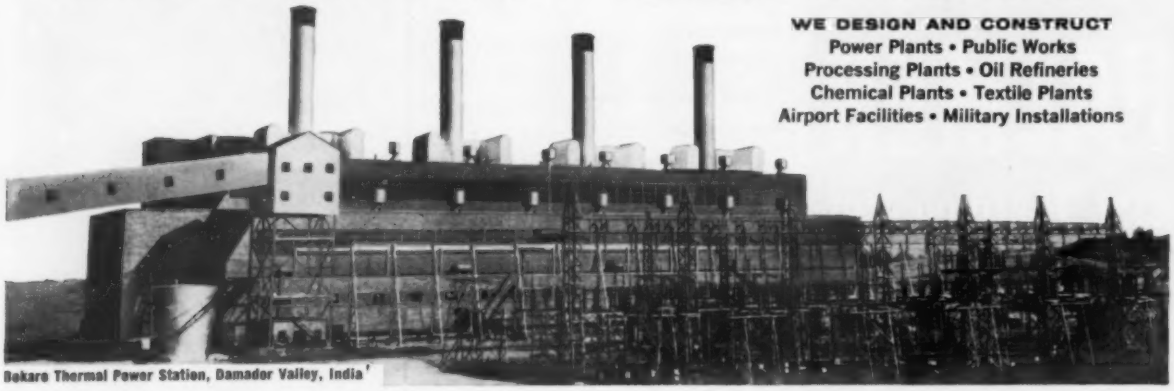

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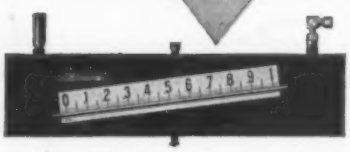

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